THE TECH ENGINEERING NEWS

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
VOL. IX, NO. 2 MARCH, 1928

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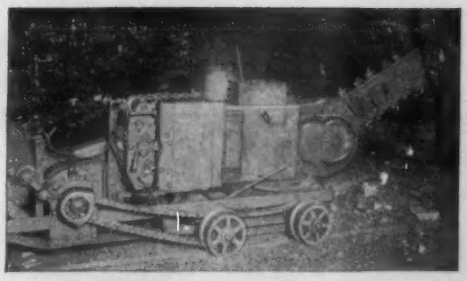
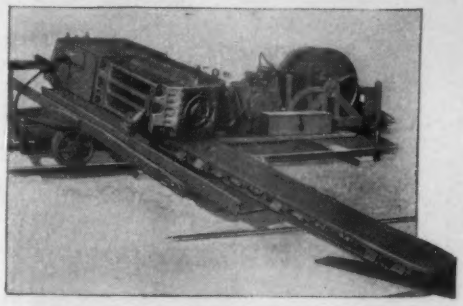
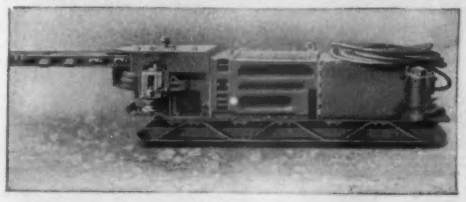


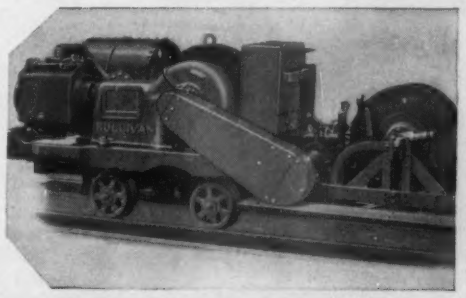
Shearing Ironclad, Sumping



"CE-7" Ironclad Unloading from Tipturn Truck



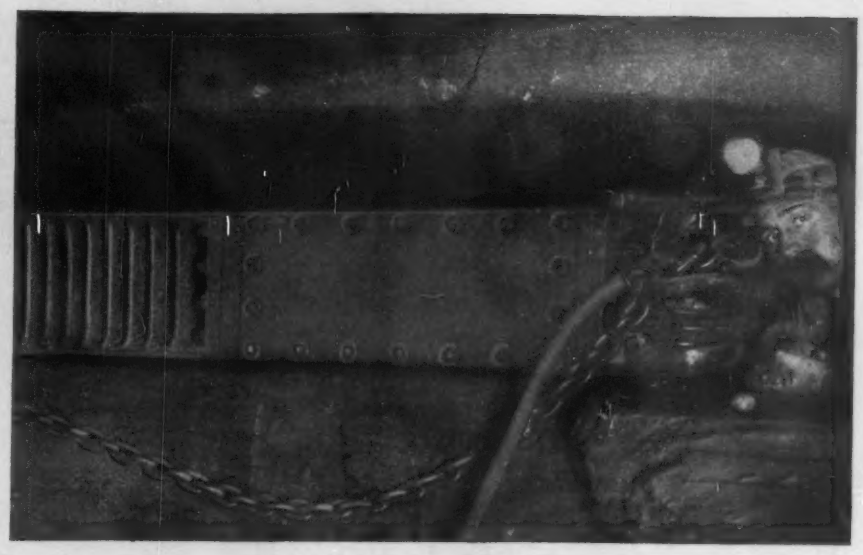
Sullivan Center Band Coal Cutter for Room Mining



"WK-39" Mine-Car Air Compressor

Sullivan Roller-Bit Sharpener

Sullivan Portable Hoist Pulling Coal Car Up a Slope



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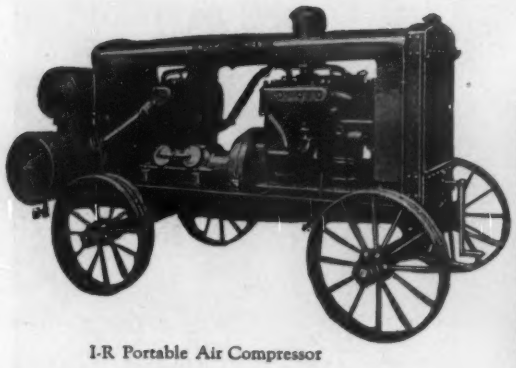
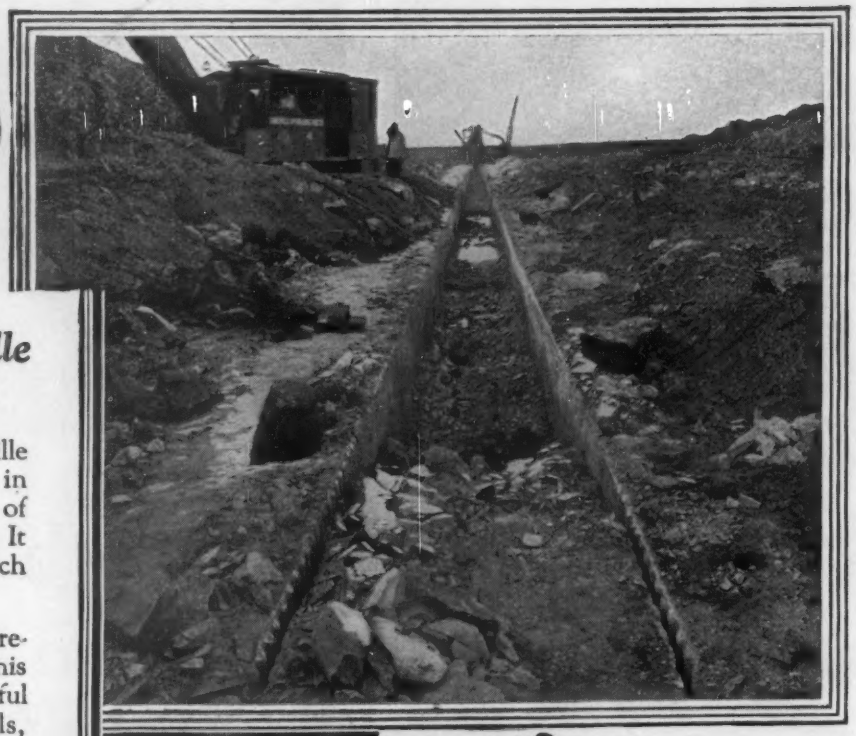


I-R Portable Air Compressor



The $10,000,000 Louisville Hydro-Electric Project

Actual work on the Louisville Hydro-Electric Project was started in the fall of 1926, and by the end of 1928 the plant will be in operation. It will ultimately have ten units, each of 10,000-hp. capacity.

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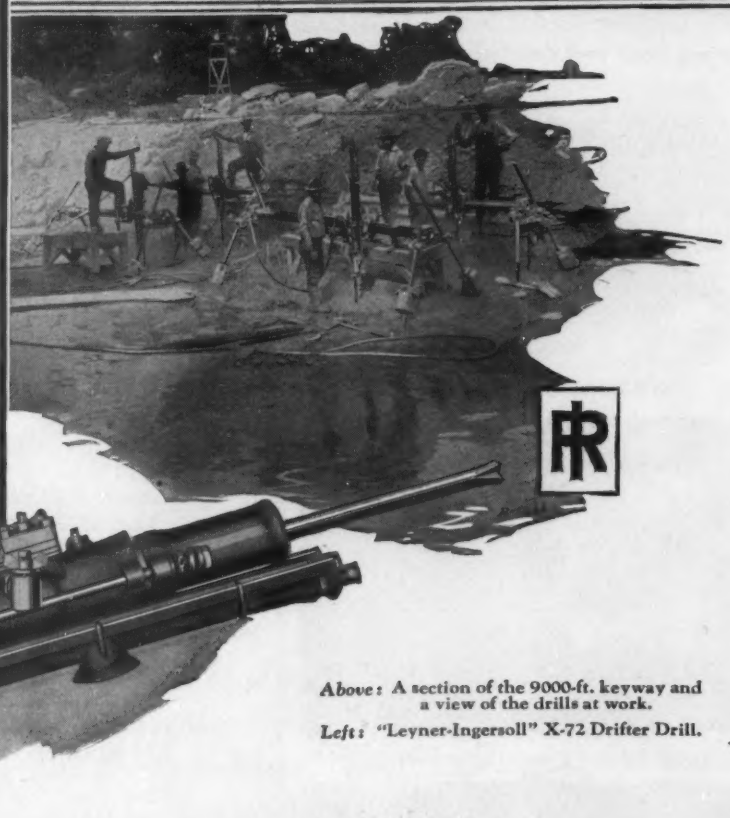

Above: A section of the 9000-ft. keyway and a view of the drills at work.

Left: "Leyner-Ingersoll" X-72 Drifter Drill.

Ingersoll-Rand

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THE TECH ENGINEERING NEWS

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73 CONTRACTS
VALUE $180,000,000

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IX MARCH, 1928 NUMBER 2

The National Research Council

An organization whose purpose is to assist in co rdinating scientific attack upon modern problems

By DR. JAMES F. NORRIS
Director of the Research Laboratory of Organic Chemistry
Massachusetts Institute of Technology

THE aftermath of the World War has yielded much of great value, and among these contributions to progress the appreciation of science is noteworthy The part to be played by the application of science in the development of the means of waging war was recognized at the start; and the men able to cope with the many problems were soon mobilized. The aeroplane, submarine, war gasses, improved explosives, new methods of signaling on land and sea, the protection of the health of the army and many other startling innovations showed the world what science could do.

The lesson was not forgotten when peace came. Industry has recognized the importance of research in its endeavor to maintain the position it had achieved during the war. A recent survey of industrial research in this country indicates that at least $200,000,000 is being spent annually for this purpose. One after another, large industrial organizations, which had been marking time, have established laboratories to make possible the advance necessary to growth.

The influence of this change in attitude is felt here at the Institute of Technology. The demand for men to help in the development of industry is greater than the supply. The man sought is of a different type from that required before the war. He must be prepared to eventually assume leadership, and accordingly must be trained adequately in the rapidly growing sciences underlying his professional work.

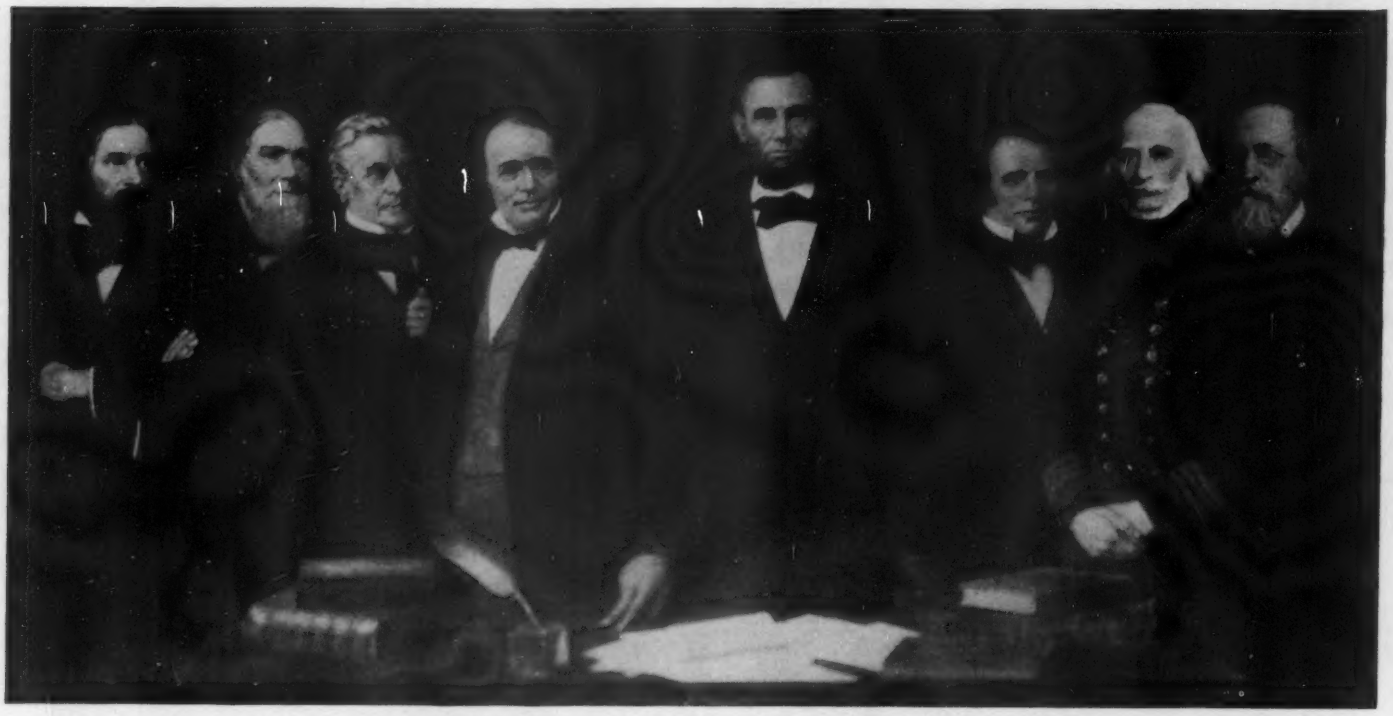
One of the most important agencies in bringing about the present satisfactory condition is the National Research Council. Its influence during the war and after is not widely recognized because it has worked quietly without any attempt to win general publicity.

The significance of science in warfare was recognized by President Lincoln when he called on some of the leading scientists in the country to advise him. As a result, the National Academy of Sciences was incorporated by Congress in 1863 to act as an advisory body to the Government. In 1916 the National Academy of Sciences offered its services to President Wilson and in order to extend its usefulness organized the National Research Council. In 1918 President Wilson requested the Academy in an executive order to perpetuate the Council and outlined its functions. These were stated to be to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful acts; to promote coöperation in research at home and abroad, but in all such undertakings to give encouragement to individual initiative; to gather and collate scientific and technical information, and to render such information available.

Dr. Norris, who describes the work of the National Research Council, has been prominent in its work for a number of years and is therefore well qualified to undertake the task of presenting its manifold duties to our readers. At present, he is a member of the Executive Council, and much of his energy is devoted to this work. A former president of the American Chemical Society, Dr. Norris is one of the leading members of his profession, and we feel honored to present his article at this time.

The work accomplished by the Council during the war warranted its continuance as a permanent agency in helping in the development of science that would come with peace. Financial support was insured by a gift of $5,000,000 to the National Academy from the Carnegie Corporation of New York. A part of the fund was used to erect a much needed building to house the Academy and the personnel required for the administrative work of the Council, but the larger portion was reserved as an endowment. The Council receives no subsidy from the Government and its resources are adequate to cover only the cost of administration. It does not itself provide funds for conducting research, but helps in procuring financial assistance for important researches from foundations, associations, and individuals prepared to give such aid.

At the start, the Council recognized the fact that men are more important than means in the winning of new knowledge. It was necessary to develop research workers of unusual ability, and a way was found. The Rockefeller Foundation gave $1,125,000 to support for the years 1919 to 1930 post-doctorate fellowships in physics, chemistry and mathematics; at present there are fifty-two holders of these fellowships. Similar fellow-



THE FOUNDERS OF THE NATIONAL ACADEMY OF SCIENCES

From the mural painting in the building of the National Academy of Sciences in Washington. It was the parent organization of The National Research Council. *Left to right:* Benjamin Pierce, A. D. Bache, Joseph Henry, Louis Agassiz, Abraham Lincoln, Senator Henry Wilson, Charles H. Davis, B. A. Gould.

ships in medicine and the biological sciences are provided for by a gift of $1,025,000 from the Rockefeller Foundation and $300,000 from the General Education Board. At present sixty-one men are preparing themselves for lives devoted to research in these fields. In addition, a number of fellowships available for work abroad are maintained by the International Education Board. Other gifts to the Council to support special undertakings have amounted to over a million dollars.

The following statement by the secretary of the Council outlines briefly the scope of the organization:

"The Council is neither a large operating scientific laboratory, nor a repository of large funds to be given away to scattered scientific workers or institutions. It is rather an organization which, while clearly recognizing the unique value of individual work, hopes especially to help bring together scattered work and workers, and to assist in coördinating, in some measure, scientific attack in America upon large problems in any and all lines of scientific activity, especially, perhaps, upon those problems which depend for successful solution on the coöperation of several or many workers and laboratories either within the realm of a single science or representing different realms in which various parts of a single problem may lie."

To provide the time and means for research in pure science by men who have already attained distinction, the National Academy of Sciences and the National Research Council are at work on a plan to raise a fund of $20,000,000 to be expended in ten years. The committee appointed to raise this sum is headed by Secretary Hoover. The responses to request for financial aid received up to the present from large industrial organizations indicate the future success of the undertaking.

Men who have been associated with the Massachusetts Institute of Technology have been active in the work of the Council since its inception. Dr. George E. Hale, at present Honorary Chairman of the Council and Professor A. A. Noyes were active in its formation; President Stratton served for a number of years on its Executive Board; Professor James F. Norris was Chairman of the Division of Chemistry and Chemical Technology in 1924-1925, and is at present a member at large of the Executive Board and the Division of Chemistry and Chemical Technology; Professor Waldemar Lindgren is chairman of the Division of Geology and Geography; Professor D. C. Jackson is vice-chairman of the Division of Engineering and Industrial Research; Professor F. G. Keyes is a member of the National Research Fellowship Board; Professor W. H. McAdams is chairman of an important committee on heat transfer between fluids and solids. Other Technology men have served as officers or members of research committees.

After ten years of existence the value of the work by the National Research Council can be estimated. The scope of its activities, the methods used, and its contributions to the advancement of pure and applied science can best be seen by considering briefly the present work of the several Divisions of the Council, through which it largely functions.

The work of the Division of Engineering and Industrial Research will be of particular interest to readers of this publication. The associations represented in the Division indicate how a wide variety of activities are correlated and coöperation is secured through the medium of the Council. The organization of the other divisions has been accomplished in a similar manner, and as a result the Council has become the center of the scientific activity of the many agencies at work in the United States. The Division is made up of representatives appointed by the following organizations: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Society of Elecrical Engineers, American Society of Refrigerating Engineers, American Society for Testing Materials, American Society for Steel Testing, American Society of Heating and Ventilating Engineers, Illuminating Engineering Society, Western Society of Engineers, Society of Automotive Engineers, American Welding Society. The work of the Division is accomplished largely through committees, which formulate and instigate research, and supervise the collection of data of value to engineers. The mere listing of the committees now at work is about all that the limited space available allows to indicate what is being done to advance the science and practice of engineering. Separate com-

mittees are studying welding wire specifications, pressure vessels, structural steel welding, welded rail joints; cause and prevention of highway accidents, character and use of road materials, economic theory of highway improvement, highway finance, highway traffic analysis, maintenance, structural design of roads; electrical insulation, fatigue phenomena of metals, industrial lighting, heat transmission, temperature measurement nomenclature and definitions, heat transfer of building and insulating materials, and heat transmission between fluids and solids.

These committees are adequately financed so that research can be undertaken. For example, the committee on heat transmission between fluids and solids, headed by Professor W. H. McAdams of the Institute has at its disposal a grant of $15,000 a year for three years and the committee on the welding of steel framework of buildings has $25,000 to be used in its work.

The Division through its executive secretary has made an extensive survey of industrial research in Europe and in Japan. The establishment in England after the war of a large number of coöperative research laboratories by the more important industries made a study of methods and results of particular value. A bulletin covering the industrial research laboratories in the United States is now in the course of revision.

The Division of Chemistry and Chemical Technology has been active in advancing chemistry in many ways. Its most outstanding achievement is the publication of International Critical Tables of Numerical Data of Physics, Chemistry and Technology. Two volumes have already appeared, two more are in press and the material to complete the total of seven volumes is now assembled. The large sum of money required to finance the undertaking (about $250,000) was subscribed by industrial organizations to which the assembled data is of the greatest value.

The Division started the publication of *Chemical Reviews*, a quarterly devoted to monographs on special topics, and in line with the policy of the Council, turned over the publication to the American Chemical Society when its success was established.

The Division has published two volumes of the Annual Survey of American Chemistry, which is prepared by a large number of active research workers. It publishes annually the reports of its more important committees, such as those on contact catalysis, colloids, etc.

The Division has been active in stimulating research, especially in industrial chemistry. Fundamental problems for study suggested by industrial organizations are available to research workers. A committee selects men to undertake such work and frequently finds financial assistance for it.

The Division was largely instrumental in having the fundamental research on petroleum carried out by the American Petroleum Institute placed under the guidance of the National Research Council. The Central Petroleum Committee of the Council acting as advisor to the American Petroleum Institute has had at its disposal a fund of $500,000 to be expended in five years in the study of the chemistry, physics and geology of petroleum.

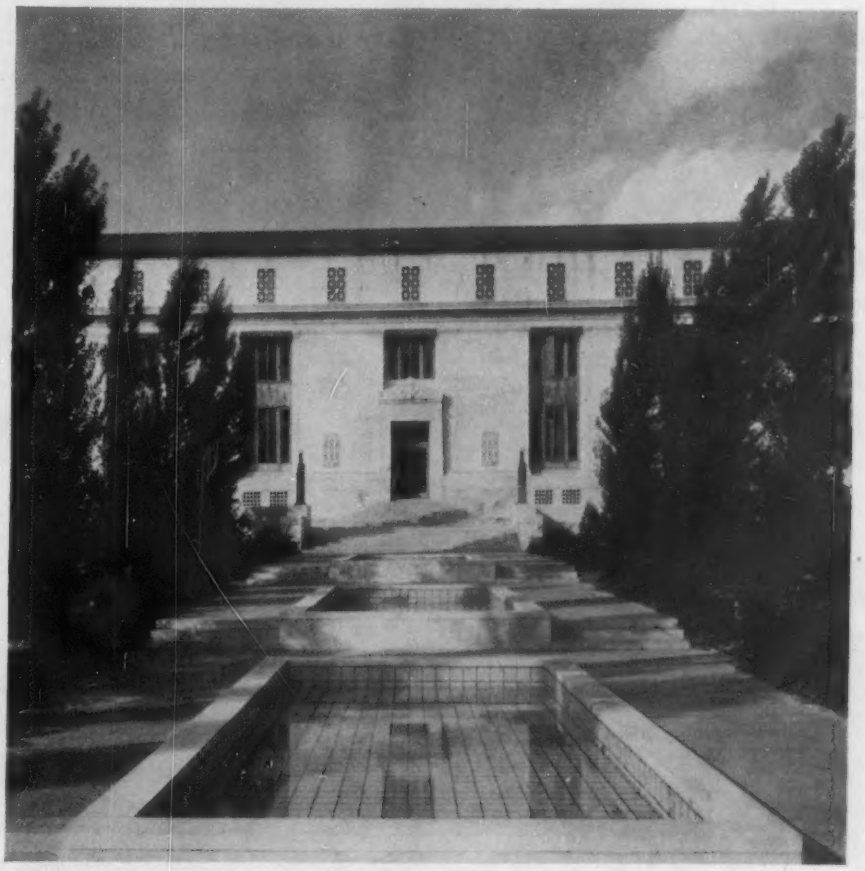
The Division has a special grant to finance a fellowship in the chemistry of sugar and is now at work on the planning of a research program for the Pine Institute, which is interested in the utilization of the chemical products obtainable from pine trees.

A number of committees are at work in special fields of chemistry. One of these instigated the annual symposium on Collodial Chemistry, the management of which was later turned over to the American Chemical Society.

The Division of Physical Sciences has devoted much attention to the preparation of monographs dealing with the recent advances in the science. The rapid growth in the last few years has made the coördination of the new knowledge particularly desirable. A committee on the relation between physics and the medical science is producing results of value in this new field. Subjects under investigation include the biological properties of light, chemiluminescence, molecular physics, receptive organs. A monograph on chemiluminescence has just been published. Authorization has been given for the preparation of German editions of the bulletins on Molecular Spectra and Critical Potentials. The International Education Board has appropriated $15,000 for the preparation of bibliography of the fundamental work accomplished in planetary research. The published monographs in physics and mathematics are listed among the publications of the Council.

The Division of Geology and Geography has a number of committees at work in special fields in which coöperation is necessary. It is represented in the Central Petroleum Committee and has furnished subjects for investiga-

(*Continued on page 76*)



THE BUILDING OF THE NATIONAL ACADEMY OF SCIENCES AND THE NATIONAL RESEARCH COUNCIL

In addition to the administrative offices, this building contains a museum illustrating recent advances in science.

Mechanical Solution of Engineering Problems

An interesting discussion of the general problem of the adaptation of mechanical aids to engineering analysis

By Dr. Vannevar Bush '16
Professor Electric Power Transmission
Massachusetts Institute of Technology

THERE has been much interest, on the part of both technical men and laymen, in the recent development in the Department of Electrical Engineering of the Massachusetts Institute of Technology of a new Integraph adapted for the solution of total differential equations. There has also been some misunderstanding of its scope and functions, and no little inquiry concerning the part it will fulfill in engineering work and the future of such devices in general. The present paper is the result. There are available* technical descriptions of the Integraph in which will be found the details of its use, and examples of its work. This paper will not repeat these descriptions, but will rather be concerned with a discussion of the general problem of the adaptation of mechanical aids to engineering analysis, and specifically with a treatment of the particular portion of this problem with which is associated the M. I. T. Integraph.

We therefore will consider briefly the relation between mathematics and engineering, to see where one leaves off and the other begins, and the types of mathematics which the engineer usually employs. Then we will inquire how the Integraph fits into this picture, how it works, and what it is good for. Finally we will speculate as to what reasonably may be expected to eventuate in the future relegation of the mechanical portions of engineering mathematics to machine treatment.

We take great pleasure in presenting this article by Dr. Bush on the Massachusetts Institute of Technology Integraph which has received a great deal of publicity in the daily press. This article aims to acquaint our readers with the purpose of the Integraph and its method of operation.

Engineering is essentially the economic application of science, and more particularly of mathematics, physics and chemistry. The attitudes of the scientist and the engineer are, and should be, entirely different. Coöperation between them is essential, and since this usually takes the form of give on the part of the scientist and take on the part of the engineer, the burden lies with the latter to see that the contact is effectively and equitably maintained. Nowhere is this relation better shown than in the relation of mathematician and engineer. For progress the engineer is utterly dependent upon the development and adaptation of powerful mathematical methods, and it is his job to see that these are utilized to the fullest extent. The end result sought by the mathematician is a formal relationship, a theorem, a law, or a formula. That of the engineer is a specific numerical result expressing in definite form the operation of a built or projected structure, machine or process. True, the mathematician often uses numerical examples the better to aid visualization of the meaning of his results, especially by those who cannot visualize directly from the formal statement. Conversely, the research engineer utilizes formal analysis in the preparation of new relationships as stepping stones toward specific results not otherwise attainable. But on the whole, formal and symbolic reasoning is the realm of the mathematician, and the application of natural laws by computation is the special field of the engineer. Engineer mathematicians bridge the boundary, and work in both regions.

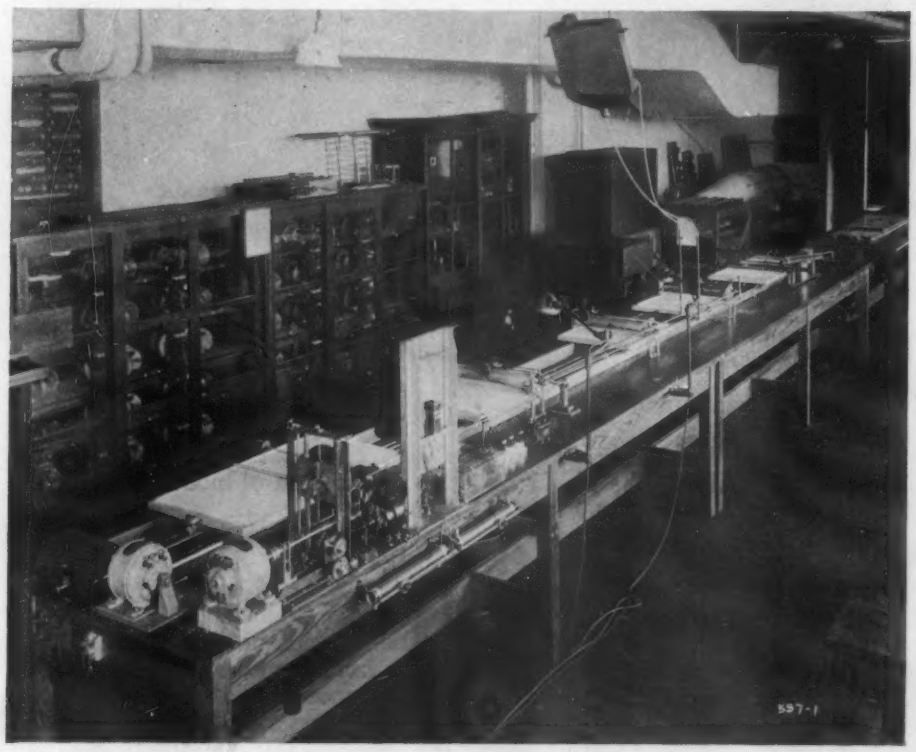
We consider in this connection, of course, only mathematics with some possibility of application, rather than that pure mathematics which partakes somewhat of the nature of an art as well as of a service, and which has its appeal rather in its aesthetic value than in its utility.

Where then, in the attack on a physical problem, does analysis leave off and computation begin? There are no labor unions present to limit jobs. It is really only a matter of convenience. The mathematician is often content with too little; he is satisfied if the problem is reduced to a single quadrature whether it can be performed or not; and considers a series solution satisfying to his soul whether or not it can yield a numerical result

*V. Bush, F. D. Gage and H. R. Stewart, "A Continuous Integraph," Journal of the Franklin Institute, January, 1927, page 63-84.

V. Bush and H. L. Hazen, "Integraph Solution of Differential Equations," Journal of Franklin Institute, November, 1927, pages 575-615.

V, Bush and K. E. Gould, "Temperature Distribution Along an Emitting Filament," Physical Review, February, 1927, pages 337-345.



A VIEW OF THE TECHNOLOGY INTEGRAPH
This instrument was developed in the Electrical Engineering Research Laboratory after several years of intense research.

in a reasonable number of computed man-hours. The engineer often wants too much; if he cannot get his computations performed for him he at least wants his formulas predigested. In this often recurring argument the engineer is usually wrong. The farther back the borderland can be pushed into the frontiers of the mathematician the more rapidly can progress be made. In order to do this economically, the engineer should call to his aid the same sort of mechanical devices that have revolutionized the detailed aspects of business, thus freeing his mind and hand from these details so that he may explore, analyze, transform and adapt, in other words engage in the higher activities of his profession. Much has been accomplished but a great deal more needs to be done. It is an economic waste to add long columns of figures mentally day by day. It is as much of a waste to perform mentally any routine mathematical process that can be relegated to a machine. As long as the mathematician has to pass out results in nice convenient simple form he is cramped in style. Some day the engineer will not expect so much, and then he will receive more. A step in this direction, and a broad high step, will be passed where equations are machine-solved to yield numerical results, whether those equations be algebraic, total differential, partial differential, or integral. Then we can say, "The problem is solved," when the equation is written. As engineering becomes more precise and more complex, this step is necessary.

Let us see somewhat more clearly where we now stand in this problem of machine computation. Of aids in arithmetic there are legion, adding machines, cash registers, accounting machines, bookkeeping machines, not to forget the humble slide rule, once the emblem of the high-brow engineer. For algebraic work we have few aids, except various graphical stunts. We solve the equations by hand processes and use arithmetic to get the results into convenient form. An exception occurs in the solution of those algebraic equations of steady vibrations which involve rotating vectors; and there are not only such graphical devices as circle diagrams, but several animated embodiments of these with historically derived names developed by Professor V. Karapetoff of Cornell, which at least enable the user to effectively grasp the relationship illustrated. The simpler differential relations lead to integrations in order to secure results, and here we find many devices; the planimeter as an integrator; harmonic analysers and their converses the synthesizers, the latter illustrated by the tide-predicting machine; and various special devices. For integrals with variable parameters very little is yet available although a good start was made on an attack on this problem last year by Dr. K. E. Gould, at Massachusetts Institute of Technology following out a very fascinating suggestion by Dr. Norbert Wiener. Incidentally, this illustrates a close coöperation between engineer and mathematician to an eminent degree. For the solution of total differential equations there have been several projected schemes, each having some degree of success. The Ford calculator, as used in fire control on warships, is a striking success in a machine that deals with calculations of this sort; and there are other such machines being developed, usually for adaptation to specific problems. Lieutenant-Commander Lawrence Wainwright, U. S. N., wrote a treatment of such a device as a thesis at the University of Chicago which is especially interesting and useful. Several conferences with him have been exceedingly helpful to the author of this article.

Photograph by Bachrach

DR. VANNEVAR BUSH '16

Where linear differential equations with constant coefficients arise we also have the "Nickleodion" brought out by C. A. Nickle of Schenectady, which works by taking an oscillogram of the electrical circuit that is arranged to be governed by the equation in hand. A somewhat similar piece of work by Mr. Fortescue of Pittsburgh involves the converse process, for it sets up a mechanical vibrating system to duplicate the swinging of a pair of electrical machines.

The Massachusetts Institute of Technology Integraph is designed to be a device for solving any total differential equation which may arise, rather than the equation of a specific problem. The form need not be linear, or the coefficients constant. Although the present model is limited to a single equation of second order the next will not be so limited. The ideas of preceding devices have been adopted to some extent, and it has been a work of collaboration on the part of many, including some who have been co-authors with the writer, Messrs. M. F. Gardner, F. G. Kear, A. L. Samuel of the Electrical Engineering Staff, and the mechanic Mr. W. F. Kershaw. It is called an integraph for want of a better name. An integrator is a device which performs an integration, and an integraph is one which writes down such a result continuously as it proceeds. The name is a misnomer, however, for its essential feature is that it goes beyond this performance and anticipates the function it is called on to integrate.

Passing on to the partial differential equation we find many devices for experimentally mapping fields of force or fields of flow, usually by the use of analogies, but no attempt as yet at any general solution by machine. Finally, the integral equation, the most powerful tool of all, has as yet not even been confronted with a machine for its subjugation. This brief review is meant to show the niche into which the integraph is being fitted, and is not intended to be any complete catalogue, for many interesting devices have not been mentioned.

This article cannot describe in any detail how the Massachusetts Institute of Technology Integraph works but an indication will be given as to the nature

(*Continued on page 66*)

Engineering in the Optical Industry

A discussion of the problems involved in the manufacture of high grade precision optical instruments

By CARL L. BAUSCH
Bausch and Lomb Optical Company

THE building of optical instruments has been largely evolutionary. A great many of them have simply grown through numerous generations of builders, but as time goes on, more constructive engineering thought is being given this subject to meet the more exacting modern demands. Clerk Maxwell was probably the first one to apply kinematics to instrument design but since his time, many minds have been working on the application of kinetic theory to the problems involved. Notwithstanding this, since constancy of adjustment and accuracy are so important, it is often found necessary to depart from the attempting geometrical point and line construction and resort to slides and surface bearings which are more practical. This fact has opened a field in which the engineer can combine theory with utility. Furthermore, the commercialization of many former "laboratory" instruments has made more necessary the consideration of the cost of manufacture, which is essentially an engineering problem.

Mason, some time ago, laid down the following seven requirements which must be met in optical instrument design:

1. An instrument must have the required accuracy.
2. It must have a constant accuracy.
3. All important sources of inaccuracy should be definitely known.
4. Adjustments should be provided for the elimination of errors as far as possible.
5. Adjustment should be possible without the aid of special apparatus.
6. Errors that cannot be eliminated should be as small as possible.
7. Errors which finally exist in the instrument should be capable of being measured so results can be corrected.

Modern conditions have added the following points which greatly complicate the problem:

Instruments must be made fool, vibration, weather and dust proof.

Convenience and ease of operation must be maintained.

Costs must be kept down to a minimum.

Although the term "Optical Instruments" really covers every sort of instrument that carries a lens, still I believe the term is more generally used to designate a class of instruments where the optics are of prime importance. This, at least, is the writer's use of the term in this article. This being the case we are safe in saying that the optical system should be the foundation in the design of an optical instrument. In many cases we are dealing with images of objects, therefore all the aberration that the lens designer has to contend with must be considered. Among the more important of these are spherical aberration, chromatic aberration, astigmatism, curvature of field and distortion. Given the lens system, the problem becomes one of dynamics, mechanics, and the strength of materials, tempered by sound engineering sense and judgment. Of course in an involved problem like this experience is worth a great deal too.

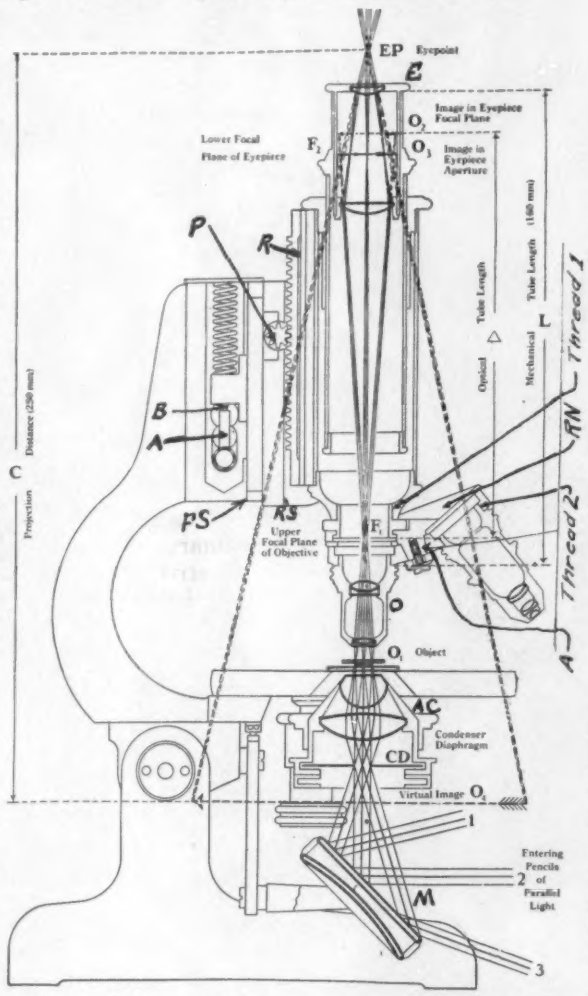


FIG. 1. Cross section of a microscope. The path of the light rays is clearly indicated.

For convenience in forming a picture of the variety involved, optical instruments may be classified as follows:

Magnifiers and Viewing Instruments	Telescopes Field glasses Microscopes Periscopes Ophthalmoscopes Photographic lenses and cameras Projection apparatus
Measuring Instruments	Measuring microscopes Surveying instruments Range finders Spectrometers Photometers Polarimeters Interferometers Ophthalmometers Refractometers

Some of these classes can be divided into a larger variety of sub classes and these sub classes into distinctive instruments.

Most of the instruments in the first class can be used for direct viewing, for visual projection, or for photographic recording or a combination of these methods.

The latest application of optics has been in talking moving picture recording and projection and in Television Apparatus. These could undoubtedly be classed in the first group of instruments.

There has also been considerable development work done recently on a class of measuring instruments where a beam of light is used as a pointer. This use of an optical lever which can be made of any length and has no weight or lag shows possibilities which will bring it well up in the world where it may almost forget its relationship to the galvanometer mirror which we have all used in the laboratory.

In many optical instruments illumination is a very important factor which ties the work of the optical engineer up very closely with the illuminating engineer.

A description of the design and method of manufacture of a standard type microscope which is one of the simpler instruments will probably serve to illustrate some of the details of the problem we are studying. I hope I will be pardoned for referring excessively to the practice of the Bausch & Lomb Optical Company in my descriptions but since my knowledge on the present subject was acquired in their organization, it is the natural means to employ.

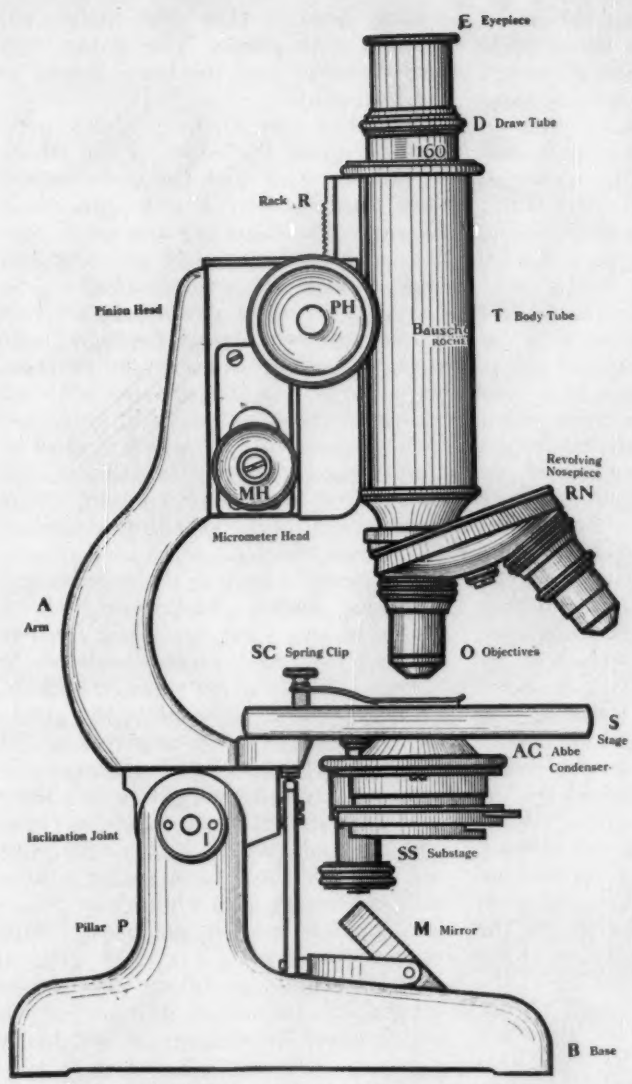


FIG. 2. A side view of the microscope shown in Fig. 1.

Figure (1) shows a cross section of a microscope with the light rays passing through the optical system.

Figure (2) shows the external appearance of this instrument. The first problem we will consider in microscope design is the optical one. The rays of light from the illuminating source strikes the mirror "M" and are reflected upward through the condenser "AC" whose function it is to gather a maximum amount of light and pass it in parallel rays up through the object "O_1."

The objective "O" comes next in the path of light and it is in the design of this part of the apparatus that the skill of the optical engineer is most highly taxed. Here all the elements of radius of curvature, thickness of lenses, air spaces, etc., are worked out in minute detail by formula based on the optical properties of the glass, the manufacture of which is a very exacting ceramic engineering problem in itself.

The eye piece "E" comes next in the optical path but is not so important as the objective.

The design of the entire optical system is calculated mathematically in all respects, but a sample is always made and thoroughly tested before any manufacture proceeds. In lens designing there are aberrations which are often not considered of enough importance to take into account just as in bridge design there are stresses which we know will exist but which are not considered because of being of minor importance. While in bridge building it is seldom possible to test a sample, in lens making it is comparatively simple to try out a design before attempting its manufacture. This trial often discloses features that can be improved, but no good optical engineer will be content to make such changes without first checking his calculations. The degree of refinement wanted in an optical system determines the extent to which calculations are carried out.

For instance, in the ordinary achromatic objective it is the usual practice to correct the chromatic aberration for two colors and the spherical for one; while in the apochromatic objective the correction for chromatic aberration is made for three colors and the spherical is made for two.

The manufacture of precision lenses demands very close control. It is fitting that optical means are used to get this control. All accurate lens surfaces are checked for proper curvature with test plates that are pieces of quartz, on one surface of which has been ground and polished a curve to fit the one to be tested. The "rule of three," *i.e.*, "two things equal to a third are equal to each other" is used in making these test plates. This is the well known scheme of checking three surface plates to each other to insure their all being flat. When the test plate is placed on the surface of the lens to be tested, light interference bands are formed in the spectrum colors just as appear when light is reflected from oil on the surface of water. The nature of these bands show to within a fraction of a wave length of light what distortions exist in the lens surface.

Figures 3 and 4 show the nature of these interference bands. Figure 3 shows what two fairly perfect plane surfaces look like when the edges at one side are slightly separated so that a wedge of air is formed between the surfaces.

Figure 4 shows the result when irregular surfaces are placed together. The bands shown in this figure are in reality contour lines showing the highs and lows in the same manner as a typographical map shows the contour lines of a country.

As the nature of the contact between such surfaces is improved these bands are reduced in number and it can be mathematically shown that when the color is reduced to a uniform straw color when viewed by daylight, that an error of only about one one-millionth of an inch exists between the surfaces under test.

Surface accuracy such as this is required on some optical work.

In order to get full value of the optics, the stand which carries them and the object must be rigid and the adjustments must be smooth working. Space will not permit a description of all the interesting problems which must be solved in bringing about this condition, so I will mention only the more important.

In order to properly focus the instrument, a rack and pinion actuated slide and a supplementary fine adjustment slide, actuated by a worm and segment plus a lever mechanism are used. These are shown in cross section as "RS" and "FS" in figure 1. An-

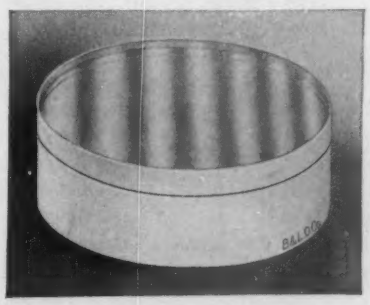


FIG. 3. Light interference bands caused by slightly separating two plane surfaces on one side, admitting a wedge of air.

FIG. 4. Light interference bands caused by placing together two irregular surfaces. The lines indicate depressions and high spots.

other cross section (figure 6) shows the other view of the fine adjustment mechanism. These slides are of dovetail cross section and must be very nicely fitted. The material for these slides must be selected with good judgment as to bearing properties, especially the fine adjustment slide which must be moved one to two hundred-thousandths of an inch without depreciable lag.

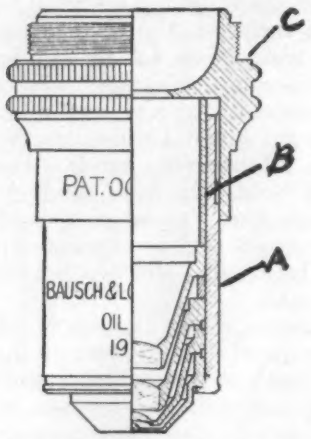


FIG. 5. Cross section of a 1.9 mm. oil immersion objective.

For the rack and pinion slide two different compositions of hard brass are usually used, while the latest practice on the fine adjustment slide is to use a combination of hard fine grained gray cast iron and brass. This slide is moved by means of the button "MH," which carries a fine pitch worm engaging a worm segment "A." The pivoted pin "B" rests on a portion of this segment which is cut away and serves as a lever. The weight of the slide which carries the microscope body tube with its optics rests on the other side of this pin. Since it should be possible to detect a movement of as small as .000010″ on this slide, it is easy to understand the care that must be exercised in the construction of this mechanism. The other worm carried on the same shaft as the fine adjustment worm is part of the stop mechanism preventing excessive motion and consequent strain. It carries a nut "N" back and forth and stop pins "SP" which engage the studs "S" in the worm shaft and prevent further movement.

The rack and pinion adjustment also presents its problems. Although this is used only for the approximate setting of the focus, a very smooth acting slide is required. Much attention has been given the design and method of manufacture of parts "R" and "P." Neither the epicycloidal or involute tooth seem to serve the purpose for the teeth of the rack and pinion which are cut spirally, but an empirical form has been developed which assures smooth running. The development and working out of these tooth shapes involved the study of their sliding action by means of projecting their image while in motion at high magnification and the building of special equipment making the necessary cutters. A detailed description of this very interesting work was described by the writer in *American Machinist* of May 11, 1922.

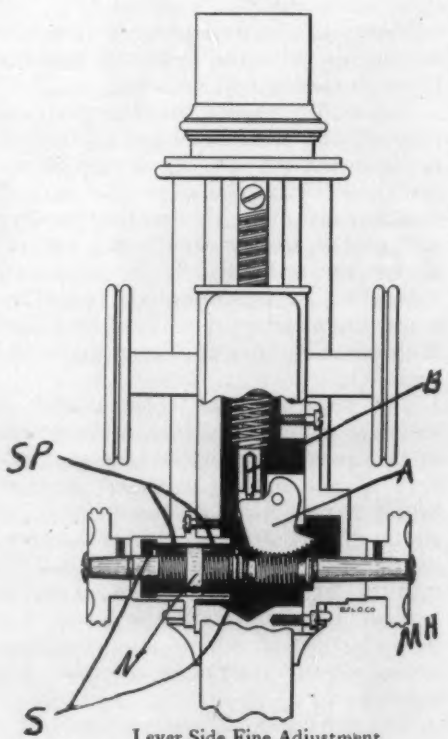
The mounting of the objectives and carrier which is commonly called a revolving nosepiece must certainly come in for a big share of discussion. The nosepiece which is shown as "RN" in figures (1) and (2) is screwed on to the bottom of the body tube by means of "Thread No. 1" and carries either two, three or four objectives around the axle "A," so that any one of the objectives can be swung around into a position of alignment to the optical axis of the complete system. The taper bearing of this axle is turned with a diamond tool to insure a true surface and, in order to get alignment, the threads and bearing surface of the threads "Thread No. 2" that carry the objective are cut on a special machine after the nosepiece is all assembled. These threads are made according to a standard established by the Royal Microscopical Society. While this standard is a Whitworth thread, American practice seems to be the use of a 55-degree thread of the same pitch diameter but without the fit on the rounded top and bottom which is the regular Whitworth standard.

The objectives are usually considered individual items as they are interchangeable, due to the use of this standard Royal Microscopical Society thread. Figure (5) shows the cross section of a 1.9 millimeter oil immersion objective. The problem in objective construction is to mount the delicate lenses in as near perfect alignment as possible with correct air spaces between them. In the construction shown the lenses are mounted in individual cells which fit in the aligning tube "A." The tube "B," the length of which determines the position of the lens system with regard to the thread shoulder "C," is faced off to the proper length by a final operation in a special outfit which turns both ends of the tube in the same set-up to insure parallelism of these faces. In order to maintain cylindrical form and constant diameter of the tubes and mounts, diamond turning is here also used. The old practice in mounting lenses for micro objectives was to cement them into place while the mount and lens were revolving in a lathe. The lens was made enough smaller than the mount so it could be moved laterally in the mount while an image of a distant object was observed as reflected from the lens surfaces. While the cement which held the lens in place was softened by means of a gas flame, the lens was so moved around that the image remained stationary. The flame was then removed and the lens allowed to set into place.

This has now all been changed so that we grind the edges of the lenses so they are true with the surfaces and then burnish the lenses into their mounts. The same old scheme of centering the lens prior to grinding the edge is used as no mechanical means have as yet been devised to do this work accurately enough for high grade work. The process used may be compared to truing the surfaces with an indicator. The indicator in this case being a beam of light which is ideal in that it can be of great length and still be without weight or friction. This construction eliminates the possibility of solvents which are often used around a microscope affecting the cement and loosening lenses. The burnishing of lenses of this kind into their mounts without causing strain in the lenses is a very difficult piece of work and requires special equipment of the greatest precision. Very little strain would result in deforming the surfaces of the lenses enough to seriously impair their performance. Strain would also cause irregular polarization of the light passing through the lenses, making them unfit for many uses where true polarized light is used in connection with microscopic work.

In the building of optical instruments for measuring purposes with which exact measurements are to be

(*Continued on page 82*)



Lever Side Fine Adjustment
(Section)

FIG. 6. Cross section showing the fine adjustment mechanism of a microscope.

The Story of Petroleum Refining

Fifteen years ago a comparatively simple art, today the production of motor fuel presents a variety of complex problems

By H. C. Weber '18
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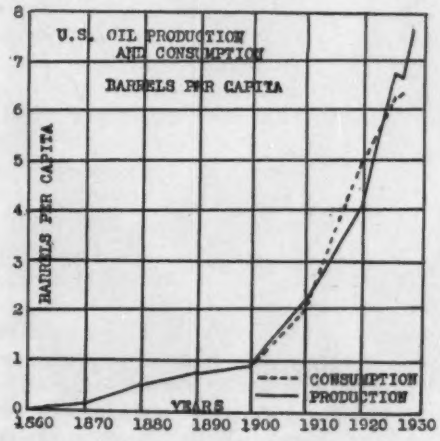
Massachusetts Institute of Technology

THE refining end of the petroleum industry is today undergoing a far-reaching transformation of vital importance, not only to the industry, but to everyone interested in automotive transportation, in the fields of lubrication and the generation of heat and power. The reason for this transformation is the changing demand for the products of the industry, particularly the increasing demand for gasoline relative to the outlets for other products, and to the supply of crude oil available as raw material. The technical development of the industry to meet the economic pressure involved in this situation is one of the most fascinating engineering accomplishments of the last decade. While it is less widely known than the story of the development of the new motor cars and airplanes, it is inferior to these things neither in inherent interest nor in importance.

The American petroleum industry came into being about three-quarters of a century ago in response to the urge for better illumination. It was discovered that crude petroleum from Pennsylvania contained components which could be employed as burning oils and which, compared with the illuminants then available, sperm oil, shale oil and to a lesser degree, Russian petroleum, were lower in cost and superior in quality. The lowest boiling components of the Pennsylvania crude oil then used were too volatile to be incorporated in kerosene because of the danger of explosion, and, while used to a certain degree as solvents and fuel, the excess represented a waste product in the industry. All higher boiling components were incorporated in the kerosene up to the point where the fraction became too viscous to flow properly up a wick. It was later found that certain of the still higher-boiling fractions possess great value as lubricants and waxes, and these developed as important by-products of the industry of petroleum refining.

The modern automobile was developed to use as its fuel the cheap by-product gasoline of the petroleum industry. For a number of years this supply sufficed but the time soon came when by-product gasoline was inadequate for the requirements of the automotive industry. The petroleum refiner first met the problem by incorporating in his motor fuel the lighter fractions



The enormous increase of production and consumption from 1900 is clearly shown by the slope of the curve.

of what had formerly been sold as burning oils, a step which had the great advantage of improving the quality of the kerosene because of the decreased risk of explosion. Unfortunately, for the peace of mind of the refiner, the demand for more gasoline did not stop at this point of happy balance and a time came when the amount in the crude, of components of volatility suitable for motor fuel, was inadequate to meet the demand. However, the industry had sufficient foresight to provide against this contingency by the development of the so-called cracking processes.

In the early days of the industry it was discovered that high-boiling oils of viscosity far too high and of volatility too low to incorporate in kerosene, could be decomposed into lower boiling materials by subjecting them to heat, preferably under pressure. A great deal of technical ingenuity was expended on the problem and remarkable progress achieved. Commercial plants were built and operated, although the scale was not large. The engineers of that day naturally focussed their attention on the production of burning oils and the limited commercial development of the process was undoubtedly due primarily to the fact that the material produced by cracking and redistillation, while thoroughly satisfactory from the point of view of volatility and viscosity, was, in general, inferior in illuminating quality to the comparable components naturally present in the high-grade crudes with which the cracked products had to compete.

When the automobile created its demand for volatile fractions for motor fuel, the industry turned to these old methods of thermal decomposition to see if they could not be modified and developed to meet the new demand. It is now realized that, whereas, in illuminating quality cracked products are inferior to the corresponding uncracked fractions from the crude, in burning characteristics, in the internal combustion engine, they are decidedly superior. Although the development of the cracking art as applied to the production of motor fuel has followed along the same general lines as the work of the preceding decades, the engineering technique of large-scale production had not been perfected and the solution of these problems has been the great achievement of the petroleum technologist during the last twenty years. To supply cheap motor fuel in the quantity required for the increasing numbers of automobiles necessitated production on an enormous scale. Furthermore, plant experience soon made it obvious that high operating pressures are desirable, particularly in the so-called liquid phase methods. It was by no means easy to solve the engineering problems involved in the efficient construction of heated pressure vessels to contain large quantities of hot oil at temperatures at which the tensile strength of steel is beginning to decrease rapidly and under conditions where coke deposition from the oil

(*Continued on page 68*)

Comparison of the Steel and Petroleum Industries of the United States

	Petroleum	*Steel*
Investment	$11,300,000,000	$4,750,000,000
Annual capital requirements last 13 years	500,000,000	100,000,000
Value of crude for 1926	1,444,000,000	
Value of pig for 1926		749,000,000

Statistics taken from O. & G. J., Vol. 26, No. 28 (Dec. 1, 1927), page 119. *Iron Age*, April 21, 1927. page 1150. Mineral Resources of U. S. for 1926, Preliminary Summary, pages A4 and A5.

The Development of Chromium Plating

A review of the research and industrial applications involving the use of metallic chromium as a plating material

By Dr. Walter C. Schumb
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Massachusetts Institute of Technology

CHROMIUM plating has become sufficiently common, and articles concerning the progress in this art sufficiently numerous, both from the standpoint of research and of commercial practice, to warrant an account in these columns of what has been accomplished in this field. The following pages contain a review of the more important articles pertaining to this subject published within the last decade. A list of references will be found at the end of this account.

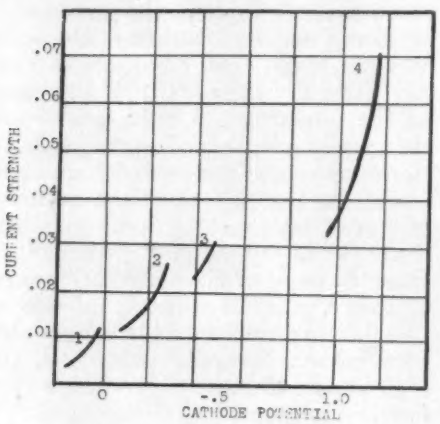


FIG. 1. The breaks in the curve indicate three successive drops in the valence of chromium as the electrolysis takes place.

We are all familiar with the fact that metallic coatings constitute one of the most important means of protection of a base metal from corrosion, as well as contributing in some cases certain other qualities — such as hardness, lustre, ornamental value — not possessed by the underlying metal.

Metallic chromium possesses several properties which make it especially valuable as a plating material for certain purposes. Thus its hardness considerably exceeds that of the hardest steel, and although stellite is said to be slightly better in abrasive wear (in the presence of emery, for example), yet in straight metal-to-metal wear chromium is unsurpassed in effectiveness. Again, this metal resists in a high degree many of the common corrosive and tarnishing agencies which attack most other metals: ordinary air, oxygen, or chlorine, up to 300°C; a continuous 20 per cent salt spray over a period of 5 days; superheated steam, sulphur compounds, ammonia, concentrated nitric or sulphuric acids have little effect; although it must be remembered that hydrochloric acid (and dilute sulphuric acid less rapidly) dissolve chromium. Its resistance to fruit acids has become familiar since the introduction of stainless, chromium-bearing steels. Furthermore, water does not readily "wet" a chromium surface, a property which adds to the value of the metal in resisting corrosion. Its platinum-like color and high lustre are other properties upon which various other uses of the metal are based.

It is nearly 75 years since Bunsen (1)† first obtained metallic chromium electrolytically by the electrolysis of a hot chloride solution (mainly $CrCl_2$ with some $CrCl_3$); and it may appear strange, in view of the excellent properties of this metal, that the introduction of chromium-plated ware into common use has been so long delayed; but it is only within a very few years that the conditions necessary for obtaining a satisfactory coating, on a commercial scale, have been worked out.

Even in the earliest work of Bunsen, it was noted that for successful results the control of such factors as the current density and the concentration of electrolyte were of great importance; and although today chromium plating is being employed industrially in various ways, both here and in Europe, research is still in progress in a number of laboratories in the hope of further improving plating conditions.

Much of the published work prior to 1920, especially the description of patented processes,* was confusing and contradictory in the conclusions reached; resulting in part, no doubt, from the difficulty of duplicating in successive experiments exactly the same conditions — so many are the variables to be considered.

To pass over, then, the earliest work (2 to 5) and some of the more recent work (6 to 12), we find in 1920 a notable contribution by G. J. Sargent (13) which has served as a starting-point for much that has followed. Using chromium-plated copper cathodes and platinum anodes, Sargent found very good deposits of chromium to be obtainable from chromic acid solutions containing small amounts of chromic sulphate; thus he got a deposit one-half inch thick from a plating solution containing 24.5% CrO_3, 0.3% $Cr_2(SO_4)_3$, at 20° C., using a cathode current density of 10 amp. per square dcm., a voltage of about 3 v., and an electrode distance of about an inch. If the 0.3% of chromic sulphate were left out, only traces of metal would be deposited, and instead a black coating — probably an oxide film — formed. Over 0.5% $Cr_2(SO_4)_3$, however, produced poor deposits of metal. He found the deposition of metal to be markedly affected by the temperature of the bath, as well as by the cathode current density and the concentration of the CrO_3 employed. Sargent's work, to which further reference will be made below, has led to the adoption of a chromic acid bath, with certain added substances, in practically all the commercial processes since developed.

Chromium has been successfully plated directly upon most of the common metals as a base, except aluminum. With iron or steel cathodes, however, the danger of cracking of the plated metal (especially when made thick enough to obviate pinhole formation), and the consequent increase in corrosion of the exposed iron, usually make it desirable to first thoroughly cover the iron with a coating of copper or nickel, or both.

The anodes commonly employed are of the insoluble type, frequently lead or steel (which does not appreciably dissolve in the plating bath).* Steel, crockery, or lead-lined tanks are used as receptacles. The very copious evolution of hydrogen at the cathode, and, to a less extent, of oxygen at the anode, produce an acid spray which is very irritating to the respiratory tract, so that the plating tank is covered with a ventilating hood to protect the workman.

*Lead anodes are said to possess an advantage over certain other metals, in that they permit reoxidation of chromium from valences lower than 6, which in part makes up for the reduction of hexavalent chromium which occurs at the cathode.

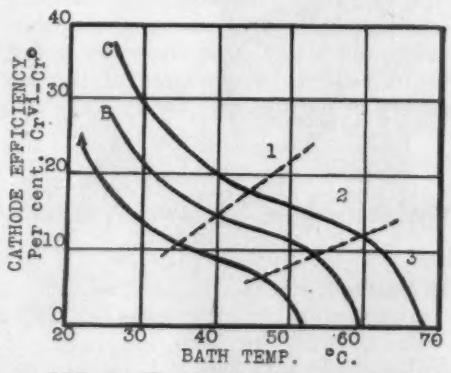


FIG. 2. The curves indicate the cathode efficiency under varying conditions of temperature and current density.

*A very complete list of patents pertaining to chromium plating, together with abstracts of their contents, will be found in Engineering Research Bulletin No. 8, published by the Engineering Research Department, University of Michigan.

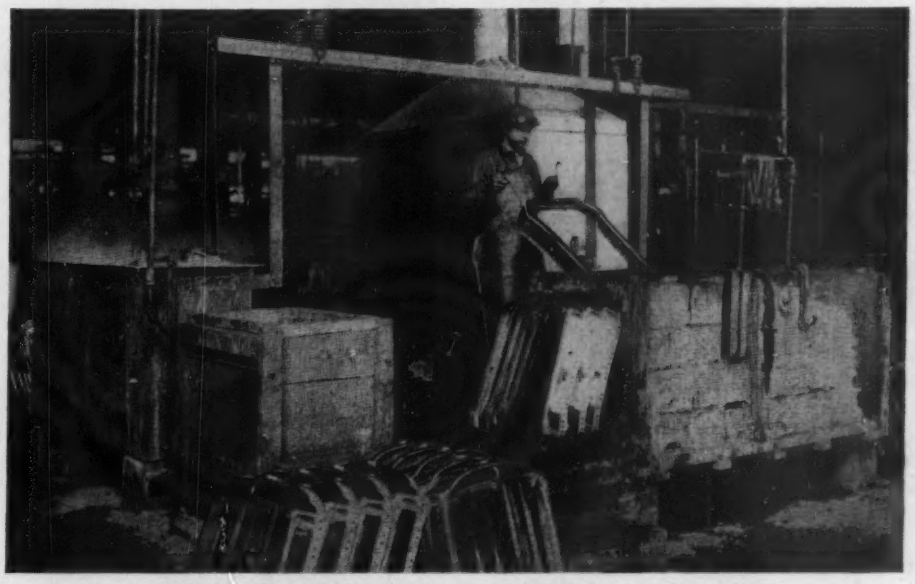
†See references at end of article.

The character of the deposit obtained varies with the conditions all the way from compact, bright, lustrous, and adherent, to a loose, coarse-grained, and dull deposit. Inasmuch as hydrogen is liberated very freely at the cathode together with the deposited chromium, the latter will contain considerable occluded and adsorbed hydrogen; the removal of this gas constitutes an important improvement in recently devised processes referred to immediately below. It is stated that 250 volumes of hydrogen may be taken up by one volume of chromium metal at a current density of about 5 amp. per square dcm., and that at 20 amp. per square dcm. the volume of hydrogen so taken up may even reach 2000 times that of the metal.

It is easily understood from the above that a chromium deposit with a high content of occluded and adsorbed gas frequently develops cracks, and the surface metal scales off from the base metal. As above mentioned, if this happens, corrosion of the underlying metal — frequently iron or steel — develops rapidly, inasmuch as chromium does not protect iron from corrosion (as zinc or cadmium do), but rather sets up a metallic couple in which iron is the corroding element (or anode).

Attempts to degasify the plated metal have recently been made. Thus von Wartenberg (15) states that clock springs, thinly plated with chromium, which had become brittle upon plating, had their original elasticity restored by heating in air at 100° C. for 2 hours (or for less time at higher temperatures). No corrosion of such objects occurred when put into distilled water. Again, Pfanhauser (16), discussing recent German practice, describes a degasifying process devised by von Bosse, which is carried on at room temperatures; this being an advantage over various high temperature methods — immersion in molten salts, etc. — in that the sudden heating causes a cracking of the chromium layer, especially if the same is of some thickness. The von Bosse process uses a vacuum apparatus containing the plated articles fastened to electrodes between which a high tension A. C. is passed, the hydrogen leaving the metal being swept out by powerful vacuum pumps. The process takes about 10–15 minutes. Pfanhauser claims that this method removes the hydrogen not only from the chromium surface but from the base metal as well, and that objects so plated and treated — *e.g.*, surgical instruments — do not remain brittle, as is the case if degasification is not applied, but rather regain their normal degree of hardness and flexibility.

The importance of the degasification of metals and its relation to corrosion is also considered in a recent interesting article by F. M. Dorsey (17), in which C. P. Madsen's method is described. In this process the metal is made the anode in 66° Bé. (96%) sulphuric acid at ordinary temperature. The voltage may be varied from 6 to 24 volts, D. C. or A. C.; the current density being 25 to 50 amp. per square foot. The cathode is a sheet steel electrode or the steel tank itself. This is not strictly an electrolytic cell, neither is the sulphuric acid strictly the electrolyte; nor is it mere pickling, since oxides are not removed by degasification. All the common base metals except aluminum may be successfully degasified in a few minutes by this method, which produces a clean, finely etched surface, promoting adherence and interlocking of the crystals of the plated metal. Thus steel plates, degasified and then nickel-plated, may be heavily chromium-plated without danger of peeling of the nickel coating; and such plates may be pressed into various shapes without flaking of the surface.



REMOVING RADIATOR SHELL SFROM THE PLATING BATH

Chromium plating has found extensive use in the automotive industry, particularly for the finish on radiator shells.

Returning for a time to the matter of the composition of the plating bath, used by Sargent and, with various modifications, by most of the later investigators; the question arises, why is the particular mixture of CrO_3 and chromic salt necessary? Let us review certain of the facts noted by Sargent:

a. If CrO_3 *alone* is used in a concentrated solution, low current densities merely reduce the chromium quantitatively to lower valences, but do not deposit the metal; higher current densities produce a dark film on the cathode and then hydrogen comes off quantitatively; with much higher current densities chromium metal may be deposited.

b. When chromic sulphate solutions $Cr_2(SO_4)_3$ *alone* are used, hydrogen is evolved at the cathode and reduction of chromic sulphate to chromous sulphate, $CrSO_4$, occurs; when considerable reduction to the chromous state has occurred, metallic chromium begins to be deposited.

c. If the electrolyte consists of a *mixture* of CrO_3 and $Cr_2(SO_4)_3$, the usual behavior of such solutions on electrolysis is indicated in the accompanying graph, Fig. 1, taken from a paper by Liebreich (14), who extended Sargent's work. Liebreich pointed out that when chromic acid solutions (with or without the presence of other chromium compounds) are electrolyzed and the current strength is plotted against cathode potential, the resulting curve in general shows four branches, with three sharp breaks, corresponding to a progressive drop in valence from hexavalent to trivalent and divalent chromium, thence to the metallic state. The deposition of metal occurs, according to Liebreich, only by the discharge of the divalent chromous ion: $Cr^{++} + 2\,(-) \rightleftarrows Cr$. In the presence of the intermediate stages of valence, double compounds, colloidal oxides of chromium containing hexa- and trivalent chromium — the so-called "chromium chromate" — or of tri- and divalent chromium, are formed; and under certain conditions brownish hydroxide deposits are formed on the cathode.

The addition of acid to the bath, and also raising the temperature, cause the branches of these potential curves to separate more widely from one another, to become steeper and more clearly defined; thus in the accompanying figure the temperature

(*Continued on page 70*)

Departmental Notes

RESEARCH WORK IN THE DEPARTMENT OF CHEMISTRY

THE general policy of the Chemical Department was described in the TECH ENGINEERING NEWS for May, 1927, and in the same place an outline of the major research projects was given. The paragraphs below give in detail the problems being investigated by various members of the Chemical Department. While the object of these researches is, in almost every case, the study of a scientific problem rather than industrial uses of chemical knowledge already at hand, the application of chemistry to industry is so universal that the practical bearing of the problem has been mentioned briefly. Upon completion of the work the results will be published in the usual chemical journals. For this reason details of the individual researches are not given at this time. Many of the investigations are far from completion and the larger part of them fit into well planned research programs, of which certain portions have already been published.

The reactivity (rate of reaction and of esterification) of hydroxyl hydrogen is being measured to determine how the structure of the alcohol series of organic compounds is related to the reaction velocity. Another investigation is being carried out upon the polymerization of aromatic hydrocarbons under the influence of stannic chloride, diolefines, and other substances. Some of these polymerizations yield materials related to rubber. (*A. A. Ashdown.*)

The relation between the pressure, volume and temperature of the gas or liquid phase is being studied from two viewpoints: first, the mathematical form of the function; and second, an experimental study of the compressibility of various liquids and gases at different temperatures, in order to determine the numerical values of the constants occurring in the equation of state or equation connecting pressure volume and temperature. The platinum resistance thermometer is the most reproducible and convenient means of measuring temperatures. It is important to reduce the readings of the resistance thermometer to the absolute temperature scale. To do this, an experimental study of the platinum resistance and gas thermometers is being carried out together with the effect of varying the pressure and of the nature of the gas. (*J. A. Beattie.*)

Carbonyls are compounds of metals with carbon monoxide, and many of them are volatile at ordinary temperatures. Molybdenum carbonyl is being studied in the hope of preparing it by a new method involving only moderate pressures. If it should prove possible to measure its vapor density, a more reasonable formula than the one now written for this compound will probably be found, as well as one in harmony with the ordinary valence of molybdenum. Preliminary work involves the preparation of metallic molybdenum in a more reactive form than any now available. (*A. A. Blanchard and M. M. Windsor.*)

PROFESSOR F. G. KEYES

In the present oil refinery methods there are considerable losses in the form of acid sludge. Much of this material consists of a mixture of diolefines. The separate diolefines are being prepared synthetically and their chemical behavior is being investigated in order to learn which ones are removed in the acid sludge and how they may be recovered by less wasteful methods. Certain classes of these diolefines are closely related to rubber. They can be polymerized into plastics and resins under suitable conditions, which are being given further study. (*F. Cortese*).

Certain classes of crude petroleum contain in greater or less proportion olefines which form the basis of manufacture for a diversity of chemical products. Very little is known of the chemical and physical properties of these olefines. Rates of reaction are being carefully investigated for individual members of this class of compound; together with the effect of light, of traces of water and of the nature of the solvent upon their reactions with bromine and iodine. (*H. S. Davis.*)

The dearrangement of urea is a reversal of a chemical reaction long known. The mechanism of this dearrangement and the effect of groups upon the ease of reaction are being investigated. A new method of synthesis involving the biuret reaction has been developed and incidentally has already led to the discovery of about 20 new chemical substances. From this work new evidence has been derived pointing to the existence of dicyanic acid, a substance whose existence has long been debated. Another new method has been developed for the synthesis of alkyl derivatives of nitroguanidines. The oxidation of halogenated metadiphenols is being studied in the hope that it might yield light on why there are no metaquinones. (*T. L. Davis.*)

The removal of impurities from argon by combustion, by arcing and by absorption is being investigated, especially in regard to the effect of temperature and the physical condition of the active material. In the arcing process gas is circulated through a calcium-tungsten arc. Changes in composition are followed by a volumnometer in the train, by spectroscopic measurements and by density determinations in a small high pressure bomb. When argon of sufficient purity is available its p, v, T, relations are to be investigated over a wide range of temperature and pressure.

(*G. Dietrichson.*)

Aggregation (combination of simple molecules into double or higher groups) in gases may be indicated by the absorption spectra, particularly in the ultra-violet region. Such phenomena are being investigated as a part of the general problem of the condition of gases. (*B. J. Eiseman, Jr.*)

Oil from porpoise jaws is used in lubricating the highest qualities of machinery, such as watches and chronometers. This oil is under investigation to determine its various constituents with a view to synthesizing it, or at least, of developing a synthetic mixture which will possess most of its desirable properties. (*A. H. Gill.*)

The heat liberated when hydrogen is absorbed in palladium has been calculated from vapor pressure curves, but comparison with some measured values discloses a discrepancy. This heat is being measured by a novel procedure in the hope of accounting for the discrepancy. More liquid ammonia will evaporate into a space filled with nitrogen gas than into an equal but empty volume. Thermodynamics gives a reasonable explanation

(*Continued on page 78*)

Editorials

ENGINEERS AS TEACHERS

The fact that so many members of the Massachusetts Institute of Technology instructing staff are prominent practising engineers in the outside world is, we think, one of the chief reasons why a Technology education is so valuable. Many of our professors are active members of outstanding engineering concerns, while others have built up for themselves wide reputations as consultants.

Such men, when coming before the student in lecture halls or recitation rooms, bring with them a breadth of experience in dealing with the practical problems of modern industry. Many times we picture the college professor as a man buried deep in his books, or in some absorbing research problem; but, in the main, our Technology instructors are far removed from this type. To them, the latest engineering practice is more than a topic for theoretical discussion. It is a tool which they themselves constantly employ in their professional work.

Much of this wealth of experience is passed on to the student through the various courses given by these men, and the student becomes familiar with the latest developments in the field into which he soon expects to enter. It is said that good scientific texts are five years behind modern practice, but an instructor who spends a portion of his time every day in engineering pursuits, is always abreast, if not a little in advance, of the rest of his profession. Contact with such a man cannot help but increase the student's appreciation of industrial problems and prepare him to solve them successfully.

KNOWLEDGE PLUS WISDOM

In our last issue we featured an article by William E. Nickerson '76 entitled, "Knowledge Plus Wisdom." We felt that Mr. Nickerson had a vital message for our student body, and the events of the past month have confirmed this belief in a striking manner.

In an editorial entitled, "Arbitrary Lectures," appearing in *The Tech* of February 13, the following statement was made in regard to the new lecture course for Juniors in Electrical Engineering:

"We hold no brief against the 'orientiation' addresses in the 6·00 course, for they fulfill their intended purpose admirably. But from glancing through the list of coming lectures in 6·02 we cannot help doubting their value to the Junior. His concern over the 'Electrical Engineer's Life,' we think, is very small. His interest over the economics of his future existence is even of less importance."

If any student taking Electrical Engineering has this attitude, he is certainly wasting his time and money remaining here, and the Institute will never miss him. On the contrary, the Institute will welcome an opportunity to rid itself of such students so that its time and resources may be used to better advantage by those who are here with a serious purpose. We may be acquiring knowledge, but any student who has the attitude of the author of *The Tech's* editorial is certainly not acquiring wisdom.

The Electrical Engineering Department of the Institute has done more than any other department to foster an educational program embracing some of the elements that Mr. Nickerson suggests, and it is most discouraging to find our undergraduate news organ voicing an idea of reproach on this wholehearted effort to make better electrical engineers. Our graduates are leaving the Institute to enter a complex civilization in which the engineer is peculiarly qualified to serve if he cares to. His training is the start, but then he must have wisdom to use it effectively. He must fit into an intricate social order in which he will have many contacts with people of other callings. His actions reflect not only on him, but on the whole profession. He must be able to make engineering a real and living force in modern society and still keep his mental balance. He can only do this if he has wisdom and a proper cultural and scientific background. The Electrical Engineering Department has tried to impart a little wisdom to us from men of experience who have traveled the road we are about to take, and who have arrived at their goal.

In *The Tech* of Friday, February 17, under the Editorial Speculum column, we find the following:

"Is it any wonder that we doubt the value of the subjects of these arbitrary lectures (casting no aspersions on the lecturer) after learning how little an impression the 6·00 lectures have made on the men? Can any present Course VI Junior recall the topics and essence of some of the addresses he heard last year? Logical and necessary though these lectures seem to the lecturer, we must reiterate that they fall short of their purpose if they fail to fire the student's mind to thought upon the subjects."

Any man who took the Sophomore lectures and who did not feel that he was being given something very worth while, lacks so many qualities necessary to the successful engineer and administrator that we feel he had better resign now, and make way for someone more worthy of the advantages of a technical education. The lectures for Juniors are a new innovation, but they are carrying on the ideas of the Sophomore lectures and developing them further. The lectures, to date, have certainly been worth while and more than justify the existence of the course.

In this same editorial this statement was made:

"No doubt this condition prevails in other lecture courses where the subjects for discourse are of such an arbitrary character. Why not ask the men what they would like to hear? Perhaps they know."

We are sure that the men do not know, and the author of this editorial probably does not know why he is at Tech. If we had enough wisdom to know exactly what we ought to be taught, we would not have to attend college, but could buy a large library and teach ourselves those things which we should learn. But, as past experience has proved that a student at college does not know what he should learn, hence, our faculties must use their experience, wisdom, and knowledge to impart to us the information which we should have in such a way that it will be most serviceable to us.

THE COVER

Among John W. Alexander's greatest works are his mural decorations in the Carnegie Art Museum at Pittsburgh. On our cover this month we are presenting one of the main panels of the series, which symbolizes the modern steel industry.

SOPHOMORES TAKE NOTICE

At the present time, THE TECH ENGINEERING NEWS is holding a Sophomore competition for the office of Publicity Manager, a Junior Board position which may lead to the position of General or Business Manager in the Senior year. It is open to all men of the Class of 1930, and offers an opportunity to obtain a responsible position on a live, prospering and growing activity. Ability to draw posters which are works of art is by no means an essential quality, although it is to be desired.

The Engineering Field

Abstracts from the leading professional and trade journals

The Gravity Method of Locating Oil Deposits was developed as a result of investigations made by the United States Coast and Geodetic Survey. It was discovered that there is a definite relation between the value of gravity and the density of the material in the earth's crust. Light or heavy deposits below the surface affect gravitation nearby and can be detected with a pendulum or gravity balance. This method is used by a large petroleum company, aiding them to determine where to drill for oil.

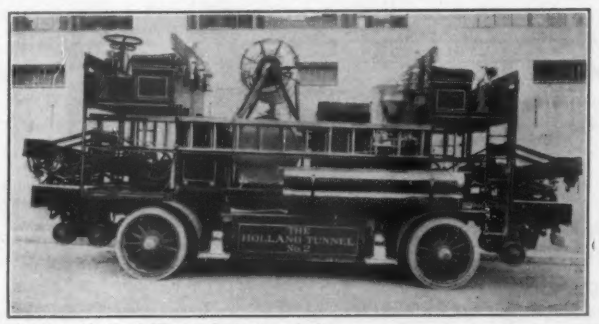
The pendulum used for the purpose is very similar to the one used by the Geodetic Survey. It is one-quarter of a meter long and constructed of invar, an alloy that does not contract or expand with changes in temperature. The plane in the head of the pendulum and the knife edge on which it rests are of agate. These are made with such precision that the pendulum will oscillate for twelve hours from the initial impulse. It functions in a partial vacuum and its period which is an index to the value of gravity, is measured by an astronomical chronometer. Determination of the difference of the period at various places makes it possible to determine the difference in gravity at these points.

The process by which the search for petroleum bearing material is made is to observe values of gravity over a proved oil field. Determinations of the change in gravity caused by differences in the density of the oil deposits from that of the surrounding material is thus obtained. A new field is then prospected by making a gravity survey of the area. If abnormal gravitations are observed at particular points a fairly good idea of the subsurface structure can be obtained.

A Method of Curing Concrete which makes pavement made by this process fifteen to thirty per cent stronger than that cured by the ordinary dirt and water system has recently been announced in the West. The system consists in spraying the wet mass immediately after it has been belted with a patented coating consisting of live Trinidad Lake Asphalt, which is held in "suspension" by a secret process. The coating forms a moisture proof covering which holds sufficient water in the concrete to effectively form an internal cure. The pavement thus formed is non-glaring and skid proof.

An Electric Thawing Machine which is especially designed to thaw underground service pipes has recently been invented. Power derived from a standard electric motor drives a special type of generator which is fitted with a field rheostat. The terminals are connected to the pipe in which the high amperage generates heat.

The machine is well adapted for use in the colder parts of the northern United States and Canada where frost frequently penetrates to such depths that house service and sometimes even water mains are frozen. The cost of thawing one pipe by this method is estimated at six cents.



Courtesy National Electric Light Association

EMERGENCY TRUCK USED IN THE HUDSON RIVER TUNNEL

Electric Wrecking Trucks have been especially designed for use in the recently opened Holland Vehicular Tunnel. They are stationed at the exits of the tunnel. In case of accident, the nearest of the policemen, who are posted every 500 feet, halts all traffic in the rear by means of a red light, at the same time sending a signal to the wrecking crew. Traffic in front is shunted to the right, making way for the emergency trucks.

These are equipped with 5-ton cranes, one located at each end of the truck. In the event of a heavier load, there is a four-wheeled dolly, capacity 9 tons, slung under one end, and a two-wheeled dolly, capacity 6 tons, slung under the other.

A double-end drive is employed, providing for operation from either end. This arrangement obviates the necessity for turning around in the tunnel.

The trucks are 27 feet long, 80 inches wide, 150½-inch wheelbase, and weigh 13 tons. They are completely outfitted with chemical fire-fighting apparatus.

Two other electric trucks have been built for the tunnel, one a tower truck, to tend the lights, the other a general utility truck. All the trucks have large battery capacity. The tower truck can be driven forty miles, the platform raised ten times, a thirty-gallon pump operated for five hours before the battery runs out. Distance, of course, is increased when the platform is not raised or the pump operated.

An Efficient Two-Cycle Engine of novel construction is a late contribution of a British designer to the automotive industry. It is an answer to the demand for a light, compact, gasoline engine resulting from the European movement towards smaller and more efficient automobiles.

The engine has six cylinders and is of the "V" type. The cylinder block is made of aluminum, finned at every possible point, and each cylinder is fitted with a steel sleeve. The whole block is covered with a cowl, at one end of which is a heavy fan, and at the other, the super-charger lead. Therefore, the air is blown around the cylinders and pre-heated before entering the carburetor. The inlet port on this engine varies from that on most two-cycle engines in that it is in the form of a circular valve and not just an aperture in the wall of the cylinder. The exhaust port is of the usual type, but instead of passing out through a muffler, the exhaust is passed through a turbine which utilizes the power otherwise lost, and at the same time muffles the sound. It was first thought that the back pressure caused by the turbine would lower the efficiency to a great extent, but experiments have shown this to be negligible.

In this engine a dyna-motor is connected directly to the fan or blower, which in turn is connected to the crankshaft. While the engine is running the dyna-motor charges a battery, but when starting, it acts as the starter motor, and at the same time being connected to the blower, a very rich mixture is immediately delivered to the cylinders.

Aside from its rather novel design and construction, this is the first British designed air-cooled automobile engine to be presented.

Concrete Lumber for the Construction of Buildings has recently been produced by a British company. It is the result of several years of exhaustive research.

The lumber is in the form of concrete T-shape slabs, board size. In con-

struction, these are placed on end and bound together by steel bands woven through the projecting ribs on the inner side. A fireproof building is thus formed, and one that possesses all the sanitary advantages offered by masonry construction.

The material due to its T-shape and internal reinforcement has in many respects properties quite similar to those of steel. It displays possibilities of reinforced concrete that have hitherto been unknown.

The new lumber is remarkable for the ease and simplicity with which it is used in construction. It was demonstrated that three unskilled workmen could erect an average size house within three days. Only forty-one of the units were necessary. The cost of the material is low, as compared to that of other building materials. It was estimated that a building constructed in this way would cost only as much as the frame under any other methods.

The Separating of Ores by a series of photo-electric cells has recently been described. The cell separates minerals and metals from the gangue or waste on the basis of the color values of the minerals selected. A series of these cells, superimposed over a moving belt, actuates small vacuum cleaner tubes which in turn automatically draw up any particle whose color tone is that of the relay system. In cases where the color differences are low, radio amplifiers are used.

The system has been used in sorting silver particles from the less valuable copper; platinum from fine black sands; removing objectionable impurities from the concentrates of other ore-dressing machines; and making concentrates of their own where previously concentration has been commercially impracticable.

A Tail-Like Device that greatly increases the speed of a motor boat has been invented. It resembles the tail of a whale in shape, and is fastened to the underside of the stern of the boat, being allowed to ride horizontally, while it is free to swing along a vertical axis. It is constructed of aluminum, and is hollow, adding but little to the weight of the vessel.

As the boat gains speed, pressure is brought to bear on this "tail" by means of a vertical piston. This piston is operated by a small air pump which creates a pressure of one hundred pounds per square inch. The "tail" is deflected from a horizontal position, raising the level of the stern. Theoretically, then, the boat rests on the bow and the depressed keel, instead of pushing up hill as it would do normally.

The propellor is thus made more efficient, as it increases the horizontal component of its force.

A Light Gasoline Hammer which is rather unique in that it has no connecting roads, cam shaft, or flywheel, has recently been invented. The pneumatic hammer has long been a favorite of the engineer, but due to the expense of maintaining a compressor, it has been used very little on light work. This new invention, which has overcome this disadvantage to a large extent, has a cylinder of the flanged air-cooled type. The piston acts directly on the hammer and when operating, it delivers about one thousand blows a minute to the anvil, which in turn transmits them to any standard tool. Operating costs are very low, as the hammer consumes but two gallons of gasoline per day.

The Chronoteine Camera is a recently invented slow motion picture machine for photographing objects moving at extremely high speeds. It makes exposures at a normal rate of 3200 per second, which can be increased to 10,000 per second if necessary. Projection of these pictures at the normal rate of sixteen per second slows down the action to one-two hundredth or less of the orginal movement of the subject. The ultra rapid camera now frequently used for slow motion purposes can only make one hundred twenty-eight exposures per second, reducing the photographed motion to only one-eighth. This is inadequate for study purposes by the scientist or engineer, and it was to fill the need of an instrument capable of recording high speeds that the new camera was designed.

At the high speeds employed in the Chronoteine camera it would be impossible to jerk the film into position for each exposure, as done in the ordinary machines. The film would be torn to pieces. It is therefore moved in a continuous stream past a fixed shutter, while the exposures are made through a series of forty-eight lenses mounted in a rotating disc. The images focused by the lenses thus follow right along with the film and overlap each other. It is possible by this method to obtain exposures of one twenty-five hundredth of a second, which is sufficient for a fully timed negative in bright sunlight. The camera uses standard film. It is operated by a four horse power motor.

Numerous uses have been suggested for the new machine. Some of these are: studies of gun recoil, shell trajectories, airplane propellor and landing gear action, propagation of flame, and engine valve rebound at high speed. These movements can be slowed down and can then be studied in detail at leisure. In addition to the economy of this method of studying motion, a record is obtained which can be referred to repeatedly with the result, as has already happened, that new and unsuspected phenomena may be discovered. The camera provides a means for the study of many problems that can not be solved in any other way.

A Self-Aligning Piston which wears evenly and eliminates wrist-pin "knock" and piston slap has recently been described by two large automobile companies.

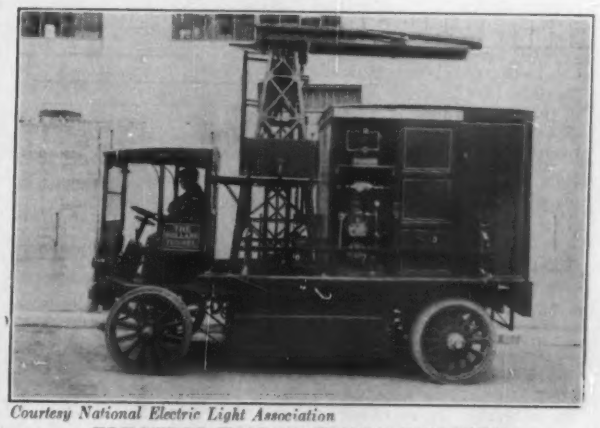
This freedom from wear is attributed to the fact that a large ball, which takes the place of the wrist pin, permits the piston to rotate within the cylinder, causing the walls to wear evenly and retain compression.

Another advantage of this piston is that adjustment may be made after normal wear merely by tightening four set screws which hold together the two segments.

The piston has already completed a 90,000-mile engine test with excellent results.

A New Insulation for Turbo-Generator Rotors was recently developed by the power engineer's department of a large electric power company. It is composed of bakelized asbestos, and is moulded into shape in steel dies under heat and pressure. It was designed to replace the mica insulation now used in large turbine generators. This frequently breaks down and is a limiting factor in the design of large machines. The new material is tough, and resistant to abrasion and heat. During the tests it showed many advantages over the old type.

Development of this new insulation improves the performance of the large machines now built, and makes possible the construction of still larger generators.



Courtesy National Electric Light Association

ELECTRIC TOWER TRUCK FOR THE HOLLAND TUNNEL

Recent Books

This department conducted in co-operation with the faculty

STEAM BOILERS. *$1.50.*

A pamphlet of about ninety pages issued by the American Gas Association, New York, New York, contains a chapter on Steam and its properties including a table of the properties of steam and sufficient explanation so that one who had not studied thermodynamics could follow the text intelligently.

Chapter II treats of Steam Boilers, their design, testing, inspection, together with abstracts from the A. S. M. E. Boiler Code covering requirements, regarding strength, safety valves, ratings, testing, etc.

Chapter III deals with the boiler power required for various industrial processes, heat transmission and film resistance.

Chapter IV takes up the calculation of chimneys and flues.

Chapter V is devoted to feed water covering pumping, purification, boiler compounds, traps and accessories.

Chapter VI and VII discuss in detail the efficiency of gas fired boilers and their adaptation to various industrial uses of such boilers.

The treatise contains a lot of useful information presented in such a way that a non-technical man can understand it. E. F. MILLER.

THE ESSENCE OF ARCHITECTURE. *By* WILLIAM R. GREELEY. *D. Van Nostrand and Co., Inc., New York City. 119 pages, illustrated.*

People in general have a good idea of what they like. Any man on the street can tell you whether or not a certain musical selection is beautiful or not. It may, or may not, be beautiful, but if he likes it, to him it is good music. Thus it is with all conceptions of beauty. Women's styles of dress in 1890 looked very well then; but to us they seem terrible. Man expresses his conception of beauty through the arts, and whether his expression is good or bad depends on the verdict of those who view it. Architecture is one of the finest of the Fine Arts, including in itself a hundred minor arts. The architects' problem is a hard one, but above all else, his creation — exposed to public view day after day — must appeal to people as being "good architecture."

There is no formula for obtaining this result. However, William R. Greeley's book, "The Essence fo Architecture," does trace in a very clear and understandable way, the essential requirements of good design. That everyone may have a clear comprehension of the ground being covered, a number of pages in the beginning are given over to the psychology of Art, and its relation to man. Then architecture is fitted into its lofty place among the Arts, with emphasis on the fact that the element of utility in architecture differentiates it from most other kinds, and the treatment from there on concerns this branch of Art.

The background a building has, plays an important part in the form it should take. Physical background concerns climate, nature, geographical setting, etc., but even more important is the background of tradition and style, which dictates whether or not the creation clashes with local ideas of what is good or bad. Unity in architecture means unity with its background, as well as unity with itself. Quoting Greeley, "To find a huge medieval cathedral in New York City is like meeting the Venerable Bede in a 'one armed lunch'." It is but a short step from the misplacement of a style of design to an actual violation of propriety.

The purpose of a design, and the design itself, go hand-in-hand. That which fulfills sincerely its purpose is automatically good design. Likewise, the architect should be true to the material he is using. In so doing he will be sure to express correctly and logically the adaptations and purposes for which that material is suited.

Personality, combined with the above requirements, is Greeley's suggestion for a method of obtaining real design. Personality, as he sees it, is composed of four properties — sincerity, propriety, style and scale. To these must be added the always admitted qualities of Unity, Balance and Emphasis.

Many problems beset an architect; that of creating picturesqueness is one. It is easily solved, for picturesqueness created, chooses to be picturesque, and becomes a violation of propriety and sincerity. The much-noted question of ornament is another problem. Some people believe ornament should express function; others believe in ornament for its own sake. A reasonable combination of the two theories is perhaps the correct solution. Decorative motives should be applied, using the same discretion and tests as were used in the whole design, and the result will turn out well.

This book is a very nice example of bookmarking. It is well printed and carefully bound. The illustrations are beautiful and very numerous.

Greeley's conclusions are heartening, and the book is written with the spirit and exhuberance of one who is proud of his profession, and glad to say he is an architect. Whether one is an architect or not, this book is well worth reading because it does portray so well the essence of that important art, Architecture.

CONSTRUCTIONAL STEELWORK SIMPLY EXPLAINED. OSCAR FABER. *Oxford University Press.,American Branch, New York City. 119 pages, illustrated. Price $2.00.*

How often is it that a student starts out on a subject with little or no familiarity with the elements and terminology of his new material. Perhaps a boy in prep school is pretty good at math, and he likes to tinker with old cars, so he figures that he'll be an engineer. Coming to Massachusetts Institute of Technology he is stuffed with Calculus, Physics, Chemistry his first year, and makes out quite well, perhaps. But with the second term of the Sophomore year comes the introduction to his chosen profession. Multitudinous new terms, new ways of thinking, new methods of procedure, are thrust upon him, and it is he that must change to fit, and follow in the tracks of those who have preceded him. If he is a student in Structural Engineering of any sort, he will haye to deal with properties of structural steel, stresses and their results, girders, methods of connections, etc. If he has gained experience through working, well and good, but if he has not, it would be a great boon to him to have something which would give him a working knowledge of the common usages of his profession.

It is for the purpose of this sort that the book, "Constructional Steelwork Simply Explained," by Oscar Faber, would prove its usefulness. It is a very elementary treatise on structural steel, containing no mathematics or formulas, and for that reason is of little use to advanced students. However, Faber's attitude is to be admired. He explains at the start the difference between mathematics and engineering, stating that math is but a tool to be used with care and judgment. A too involved use of math creates a false impression of accuracy, for it is of no use to work out a stress to four decimal points when the assumption on which the formula used is based may be in error as much as ten per cent or more.

Things are explained in a very plain, clear language. The concepts of stress and strain are put forth in a way everyone can understand, and the tests used in classifying steels explained. One is liable to think of the factor of safety as merely a "good measure" factor, but it really has a very definite reason for being. Examples of bad workmanship, faulty material, etc., are given.

It is like teaching engineering as we were taught our A, B, C's in the first grade, and after all, we did learn our A, B, C's very thoroughly.

THE AMERICAN AIRCRAFT DIRECTORY FOR 1927, *published by Aviation Publishing Corporation, Fisk Building, Broadway and 57th Street, New York City, cloth bound $5, paper $3.*

This book is presented by the publishers of "Who's Who in American Aeronautics" and "Aviation," the oldest aeronautical publication in the United States. It parallels the Annual Year Book of the Manufacturers Aircraft Association and to some extent the Trade Directory of the Aeronautical Branch of the Department of Commerce, but it also contains a great deal of information that is not found in either of these publications. There is a section entitled "Educational" which lists all graduates of aeronautical courses at eight universities giving this sort of instruction. However, the Directory fails to record the nature of the courses given. Another part of the book lists the personnel of the governmental departments and national organizations responsible for aeronautical development in the United States. The Air Commerce Act and the Air Commerce Regulations as well as the Air Corps and International Flying Rules are reprinted in detail. There is a section devoted to the accomplishments of our pilots, which gives the names of the American Aces of the World War and the winners of World and United States Air Records. One value of the book lies in the fact that it has brought together for the first time a mass of information which shows the status of the art of aviation in the United States. On this account it will be of special value to anyone actually connected with commercial aeronautics. Although the information is presented in a concise form, the arrangement is rather poor as might be expected from the first book of its kind. Photographs and information of historic value only are scattered through the book in a haphazard way.

W. G. BROWN.

THE WORLD OF ATOMS. *By* ARTHUR HAAS, PH.D., *Professor of Physics, University of Vienna. Translated by* HORACE S. UHLER, PH.D., *Associate Professor of Physics, Yale University. D. VanNostrand Co., Inc., pp. 139+xi octavo. Price $3.00.*

Many of the Institute people will remember one or two most interesting lectures by Professor Haas during the school year 1926–27 when he visited the Institute as a part of his tour of American Universities. He spoke here on the relation of matter and energy, on the probable cosmic interchangeability of one into the other, and, on the basis of the theoretical mass of energy

$$\frac{\text{energy}}{C^2} = \text{mass}$$

where energy is expressed in ergs, mass in grams, and c is the velocity of light in centimeters per second or 3×10^{10}. He showed what enormous amounts of energy would be available if we could initiate and control the annihilation of matter, or rather, the conversion of the fixed and unavailable energy supposed to be inherent in matter into diffuse radiant and heat energy. He showed how the radiant energy given off from hot stars and the sun is probably supplied through the diminution of the mass of these bodies and he speculated as to where and how in the universe

(*Continued on page 82*)

Where "good enough" isn't—

MASS cheering and singing to be truly effective nowadays must be well organized. Ask any cheer leader how long he thinks the "good enough" cheering of a few years ago would get over today!

Through telephone making at Western Electric there weaves this same progressive spirit of dissatisfaction. It has led to such developments as the creation of new practices in ceramics, the radical revision of existing warehousing and distributing methods, the discovery of new applications of chemistry and physics to manufacturing processes.

And still the work goes on. Still the world opens up for the man with the question-mark mind.

Western Electric

SINCE 1882 MANUFACTURERS FOR THE BELL SYSTEM

Mechanical Solution of Engineering Problems

(*Continued from page 53*)

of the device. A total differential equation expresses the relation between functions and their derivatives. A transformation will always change this to a relation between functions and their integrals. Integration can be made more precise than differentiation, and hence is used by preference. In the integraph the processes of integration are carried out electrically or mechanically. A mechanical interconnection between the parts forces the machine to move in such a manner that its motion is limited in just the way specified by the equation in hand. The equation states that we are to do certain things and the machine is so connected as to do them. A simple example will make this clear. The equation

$$\frac{d^2y}{dx^2} = y$$

can be written

$$y = \int\int y\,dx\,dx$$

and this specifies that we are to find a relation $y = f(x)$ such that when this curve is integrated twice we will get the same curve over again. Hence the machine is set to integrate twice a "something" which we do not yet know, and write down the result. The "something" being integrated is to be inserted in the machine by moving an index. So we connect the recording pencil in such a way that wherever it moves, the index is bound to follow it. We are now ready to go, and start the machine. The pencil moves off, drawing a curve. Everywhere it goes the index goes with it, so that at every instant the "something" that is being integrated is forced to be the result of the integration up to that instant. Thus the machine can move in only one way, and that way draws the desired solution. We have left out of consideration, so far, the question of constants of integration or the lower limits of integration. These are determined to fit the problem in hand by the position from which the machine starts, that is, the initial relation of its parts. More complicated equations can also be readily treated. In general the coefficients of the equation are plotted, placed on platens, and followed by indices as they move, and the recording pencil draws curves of solution. Complexity, caused by variable, discontinuous or even multiple valued coefficients, introduces no difficulty except for a little more work in plotting the coefficients.

Thus, to solve

$$\frac{d^2y}{dx^2} = y \sin\frac{(dy)}{(dx)} + \epsilon^{ax},$$

a rather startling relationship from a formal standpoint, we would be called upon to plot, for insertion in the machine, a sinusoid and an exponential.

The present model is unduly large, accurate only to within one or two per cent, and limited in scope to the second order. Another machine is projected and now being designed which will be more compact, more accurate, and much more versatile. The scope or order of the equations solvable is limited only by the number of units installed, no new fundamental ideas being involved; but considerable improvement in details of construction is possible. It is comparatively simple to make a device of this sort on paper. The attainment of accuracy in practice requires a close attention to such mechanical matters as friction, backlash, time lags, elastic yielding of parts, and temperature effects.

An accurate, comprehensive machine of this sort is inherently expensive, and hence we will see few such machines built for some time. Rather it is to be expected that there will be a few centers where work of this sort will be carried on, and where such devices will be available to those who can use them to advantage.

The present device has already been used for a number of interesting pieces of work.* It will, of course, for some time be primarily useful as a research tool, but it is capable of engineering service on immediate problems. It is adapted for such problems as those of continuous beams, electrical machine behaviour, vibrations in mechanical structures, ballistics, stability analyses, electrical circuit relationships, especially with non-linear elements such as rectifiers or thermionic tubes, and so on. Enough has been written to show that there are many engineering computations it will not do, for example the engineering solution of such differential equations as those describing the very important problems of fields of force and flow, the aerofoil, the hydraulic turbine, and the resistance of a ship. These call for treatment of partial differential equations of great complexity, often not even formable. It fills only a small niche, and that as yet very imperfectly, but its usefulness will expand as it increases in precision, convenience, reliability, and power.

One thing more this machine will do, an intangible accomplishment but none the less real. It will give the man who studies it a grasp of the innate meaning of a differential equation which is a worth while result in its own right. The understanding of the underlying philosophy of the calculus is far more important to the engineer than any amount of parrot-like knowledge of formal transformations and identities. There are many successful engineers who long ago forgot how to integrate by parts, but no engineer who lives in a world that moves can ever forget to reason in terms of rates; no engineer can deal effectively with the present who does not instinctively formulate in his mind the integrated functional relationships that the present bears to that which has gone before and is to follow. Before a man can build with his own hands a seaworthy boat he must patiently learn to saw to a line and plane to an accurate surface. The spirit of the calculus can enter into an engineer's mentality much more readily when he is thoroughly familiar with its symbolic language and elementary relationships. Yearning to use woodworking tools is a joy if one has a vision ahead, but sawing to a line is dull work indeed if one simply saws to a line. The study of engineering mathematics becomes soul-satisfying only when one begins to grasp the power that lies in the ability to think straight in the midst of variability and complexity, and visualizes the relation between such reasoning and that engineering accomplishment which is useful and admirable, seaworthy and a thing of beauty. Only too many terminate their mathematical apprenticeship before their mastery develops. If some few who are thus tempted, whose patience has been tried, will study the Massachusetts Institute of Technology Integraph and really understand it, one part at least of formal mathematics, the total differential equation, will become a live thing; and the existence of this device will be justified if it never draws a useful curve. All mechanical aids to mathematics have similar possibilities, and that without a doubt is a potent reason why they are so fascinating.

We once heated houses by wood fires in cast iron stoves. Then came furnaces, and automatic fires. Some of us now buy our heat units as we do gas or water. Once we kept books by longhand and mental addition. Then came typewriters, cash registers, adding machines, and now automatic accounting machines which run perpetual inventories and perform other

(*Continued on page 78*)

*This appears to be an excellent opportunity to bring to the attention of Tech men the fact that the Department of Electrical Engineering welcomes any opportunity to make the Integraph available in connection with problems for which it is adapted, and which may arise in thesis or other investigations.

The Best "Line" on Any Car—

The presence of Timken Bearings *is* an accepted sign of excellence in motor cars. How soundly can the public judge in this way? Some recent tests by car manufacturers, entirely in their own interests, are very illuminating. It was found that one factor—Timken Bearings!—made the pinion mounting, for example, *twice as resistant* as otherwise to the chief causes of wear and noise!

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THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**

The Story of Petroleum Refining

(*Continued from page 57*)

tends to insulate the inner surface of the container and cause localized overheating of the containing walls. At first, in the commercial cracking operations in this country, direct-fired cylindrical shells were used, but these were soon displaced by units in which the heat was applied to tubular surfaces of small diameter. Later, forced circulation through tubular heaters was developed, the main container being unheated. Through developments in the technique of construction and operation it has been possible to increase both the size of the units and the pressures under which they operate, resulting in important economies and reduction in cost.

The second problem was separation of the products. The effect of heat on high-boiling petroleum hydrocarbons is to break them down, not into one component, but to form an infinite number of products of volatility varying from that of methane boiling at 119 degrees below zero Fahrenheit to that of fractions so high that they cannot be boiled without thermal decomposition, even under the highest attainable vacuum. It was found that it is economically advantageous to carry the cracking operation itself only a limited degree, following this by separation of the products, with recycling of high-boiling fractions to the high temperature zone.

The different engineers working in this field approached this problem in different ways and in consequence we have today several important cracking systems, all operating on the same fundamental principles, but differing in respects which need not be considered here.

The gasoline originally present in the crude is some twenty-five per cent, on the average. Today the additional gasoline produced by cracking the higher-boiling fractions, which as such are unusuable as gasoline, has increased the gasoline production from the crude run in this country, to about forty per cent, and this can be raised to sixty per cent without appreciable modification of the best modern methods. For the last few years the industry has been swamped with a flood of crude so that it has not been necessary to crack deeply. Every one is agreed that this abundant crude supply cannot last indefinitely; the only point of disagreement is as to how long it is likely to last. Whatever the answer to this question, the technical development of the cracking process during the last twenty years has put us in a position where we can accept with relative equanamity a shrinkage of our crude oil to a point far below its present value, with no fear as to the adequacy of our motor fuel supply, no matter how rapid the increase in the number of automobiles is likely to be. None the less, the time is sure to come when our supply of motor gasoline from petroleum will be inadequate for our needs. Less than five years ago this danger was giving serious concern to the leaders of the industry but the technical developments of the recent past have already rendered it innocuous.

While for three-quarters of a century petroleum has been the only important source of both burning oils and motor fuels, there has never, during that period, been a time when other raw materials were not given serious consideration. Before the discovery of Pennsylvania petroleum the shale-oil industry had been developed in the north of England as a source of burning oil and lubricants. Furthermore, while the competition of petroleum seriously limited the use of shale, the latter industry was able to survive on a small scale and even expanded during the war. About ten years ago serious doubt arose as to the adequacy of our petroleum reserves and a widespread interest in the potentialities of shale was aroused, especially since enough shale was in sight in the United States to supply our motor fuel for centuries. While it is appreciated that the use of shale involves the mining and processing of a large amount of inert material, yielding a product which must be subjected to at least as much refining as crude petroleum, none the less the cost of production of gasoline from this source would not be such as to impose a serious handicap upon the user of the automobile. However, the development of the industry in this country would have involved serious difficulties. Our richest deposits are in arid districts of the west where the cooling water necessary for refining is not available in adequate quantity. The equipment for the initial distillation is expensive and subject to heavy depreciation. In order to meet the gasoline need of the country from this source, the investment required would be excessive. Despite these handicaps, it looked, a few years ago, as though the development of a shale industry was imminent as the only practical solution of the problem of diminishing supplies of crude. Temporarily, however, any such necessity was averted by an influx of crude from new fields greater than any hitherto known. Meanwhile, developments along other lines have relegated shale processes to the status of museum curios.

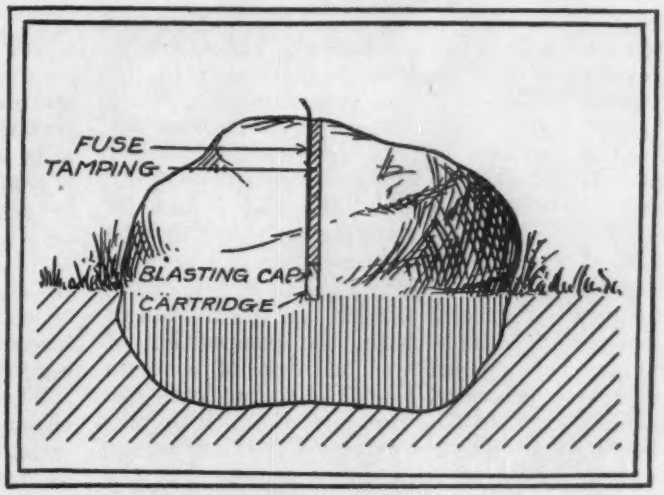
The Germans would never have dared allow the World War to start without an adequate supply of nitrogen for explosives. Shortly prior to the war they had developed the Haber process for the conversion of atmospheric nitrogen to ammonia and this process was the mainstay of their explosives production throughout the struggle. The Haber synthesis required operating pressures of two thousand pounds and upward, pressures that had never before been employed in large scale manufacturing industry. The success of the Haber technique convinced the chemical world that high pressure methods possess potentialities hitherto undreamed of. In consequence, laboratories everywhere began intensive campaigns of research, looking toward the industrial utilization of pressure. These investigations have been particularly productive in the development of new ways of manufacturing liquid fuels, ways of such promise that it seems almost certain that the best of them will be the ones to which we shall resort when our supply of crude begins seriously to diminish.

The first of these to attract widespread public attention was the methanol process of Patart. Patart takes water gas from coke, purifies it carefully, modifies its composition so as to increase its percentage of hydrogen, compresses it and passes it at a temperature of around 700 degrees Fahrenheit over a suitable catalyst, such as a mixture of the oxides of chromium and zinc. Except for the disadvantage of low heating value per gallon, methanol is a splendid motor fuel, especially when blended with other suitable constituents. Patart's achievement first brought home to the general public the possibility of large scale production of cheap motor fuel from coal.

A process which has had considerably less publicity is that of Fischer. This involves the conversion of a gas essentially indentical with that treated by Patart directly to gasoline hydrocarbons, by passing over a suitable catalyst without, however, the use of high pressure. The data at present available indicate that the catalysts hitherto developed have too low a capacity to be of industrial significance, but one can never tell when the discovery of a more efficient catalyst will render such a reaction of predominating importance.

Some fifteen years ago a German university professor undertook a series of researches, the purpose of which was to determine the chemical constitution and character of coal. It had long been known that coal contains less hydrogen and more oxygen than petroleum, but Professor Bergius dis-

(*Continued on page 74*)



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The Development of Chromium Plating

(*Continued from page 59*)

was 40°C.; at 18°C. all the curves are displaced downward and the breaks are ill-defined. Deposition of chromium (and liberation of hydrogen) occurs only along branch 4; along the other branches electrolysis proceeds with no deposition of metal: change of valence occurs and hydroxide films may be deposited. Now it is evident from these curves that the higher the acidity (or the higher the temperature), the greater must be the applied potential in order that chromium metal may deposit (branch 4). Hence in practice where in general low current densities will prove economical, it will be best to have as little free acid as possible; but, in order to keep well outside the zone of film formation (lower branches), a somewhat elevated temperature (40°C. to 50°C.) will then be required.

H. E. Haring (18), working at the Bureau of Standards, in discussing the chromic acid plating bath, also decided that the control of the acidity of the bath was most important in determining the character of the deposit, and stated that the presence in the bath of the colloidal double compounds — "chromium chromate" — acts as a check on the variation in acidity, as a "buffer": any excess of acid is used up in reacting with the colloidal oxide, regenerating chromic acid and chromic salt, whereas decreased acidity (increased alkalinity) is offset by a production of more of the colloidal oxide. The buffer may be added as such to the bath, or it may be produced by the addition of a basic or a reducing substance, or by the choice of suitable anodes. In the Bureau of Standards bath, the composition of which follows, addition of a basic carbonate, $Cr_2O(CO_3)_2$, produces the colloid, the presence of which is indicated by the change of the clear orange solution to a duller brown. For the sake of comparison, the composition of the bath recommended as best by Strausser (19), who summarizes the research carried on in the General Motors laboratory at Detroit, is also given here.

BUREAU OF STANDARDS
PLATING BATH

	gm. per liter
CrO_3	250.
$Cr_2(SO_4)_3$	3.
$Cr_2O(CO_3)_2$	7.
Temp.	45° C.
Voltage	7 to 9
Current Density	100 amp./sq. ft.

GENERAL MOTORS
PLATING BATH

	gm. per liter
CrO_3	200.
$Cr_2(SO_4)_3$ scales	5.
H_3BO_3	3.
Temp.	45° to 60° C.
Voltage	3.6 to 4.8
Current Density	100 to 400 amp./ sq. ft.

F. R. Porter (20) recommends the same substances given above in the Bureau of Standards solution, but states that the CrO_3 may be varied from 120 to 240 gm. per liter, and the basic carbonate from 7.5 to 15 gm. per liter; but that more than 3 gm. per liter of $Cr_2(SO_4)_3$ reduces the throwing power of the solution. For plane surfaces the current density may be from 70 to 350 amp. per square foot, irregular surfaces requiring 200 to 250 amp. per square foot to cover recessed parts.

Van Derau (25) gives details of the process used by the Westinghouse Electric and Manufacturing Company in the plating of reflectors or electrical apparatus (especially brass and copper). The Westinghouse bath does not employ $Cr_2(SO_4)_3$, inasmuch as Van Derau claims that the commercial variety of CrO_3 always contains about 1% of sulphate. The solution contains, for each liter *of water*, 450 gm. of CrO_3 and 15 gm. of "iron chromate" — probably basic ferric chromate — which it is claimed increases the throwing power and makes possible the use of lower current densities. The further details of the process in a general way agree with those employed elsewhere, the chromium being plated over nickel on copper or brass work, especial care being taken in the cleaning and polishing prior to nickel plating.

The separate steps involved in the chromium plating of fairly large objects, such as automobile radiators, as employed by the Olds Motor Works (23), are briefly as follows: (1) polishing the piece, as it comes from the stamping machine, on emery wheels; (2) cleansing in a solution to remove buffing compound; (3) copper plating from a cyanide bath (20 minutes); washing with hot water; (4) nickel plating from a hot chloride solution (40 minutes); (5) buffing, cleansing, and dipping in hot water; (6) chromium plating for a few minutes (depth of 0.0006"); (7) rinsing in cold water. No final buffing is needed: a glass-like finish being obtained on a buffed nickel surface.

Perhaps the most serious disadvantage inherent in the present chromium plating process is the marked lack of throwing power of the solutions used, by virtue of which irregular objects with recessed portions fail to be evenly covered: parts nearer the anode become heavily plated, while those farther away are thinly coated, if at all. When irregular objects are to be plated, therefore, either multiple anodes are employed, or the anode may be shaped to fit as closely as possible the contour of the cathode. Otherwise, excessively high current densities are employed, so as to cover, even if irregularly, the whole object.

The cause of this poor throwing power on the part of chromium plating solutions lies in the marked drop in the efficiency of metal deposition with decreasing current densities. The foregoing curves, Fig. 2, given by Haring (18), show the effect of varying current densities, and of varying temperatures, upon the cathode efficiency. Curve A applies at 50 amp. per square foot; curve B, the "operating curve" at the Bureau of Engraving and Printing, applies at 100 amp. per square foot on steel plates (or 200 amp./ square foot on nickel electrolytic plates); and curve C at 200 amp. per square foot. Areas 1, 2, and 3 are those wherein, respectively, (1) matte, frosty,

(*Continued on page 72*)

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The Development of Chromium Plating

(*Continued from page 70*)

or burnt grey deposits; (2) bright, lustrous deposits; and (3) milky, bluish, scant deposits are formed. Haring concludes that a bright deposit can thus be obtained over a wider range using high current densities at high temperatures than under the reverse conditions. In practice they employ, as stated above, a temperature of about 45° C., a current density of 100 amp. per square foot (on steel), the cathode efficiency being about 12 per cent.

To enumerate all the applications which have already been made of chromium plating industrially would constitute an article in itself, but some of the outstanding uses of this metal coating may be noted here, as follows:

In the automobile industry: radiator shells, bumpers, lamp bodies and reflector linings, valve stems, crankshafts, bearings, cams, and various other small parts heretofore nickel-plated. In plumbing fixtures; surgical instruments; electrotypes; various articles of hardware, as railings, door kick-plates, electric lighting fixtures; rubber tire molds, glass molds, and rollers for both plate glass and paper; gages, scales, and other precision tools; watch cases; pipes and surfaces exposed to the fumes of nitric acid or the sulphur compounds of petroleum (cracking stills); electric irons and "greaseless" frying-pans — in these and many other similar uses* the unique properties of chromium find valuable application.

In conclusion, it may be said that while metal ware is subject to many ills and it is not to be expected that the process of chromium plating will prove a remedy for, nor even become a substitute for all of the other well-established methods of plating, it is safe to predict that when chromium plating is used in conjunction with some of these, for example, when used as a flash coating over nickel or copper, the future promises the increasing usage and wide-spread adoption of this practice.

*For further description of such applications of chromium plating in industry, see the recent articles by Humphries (21), Killeffer (22), and Blum (24).

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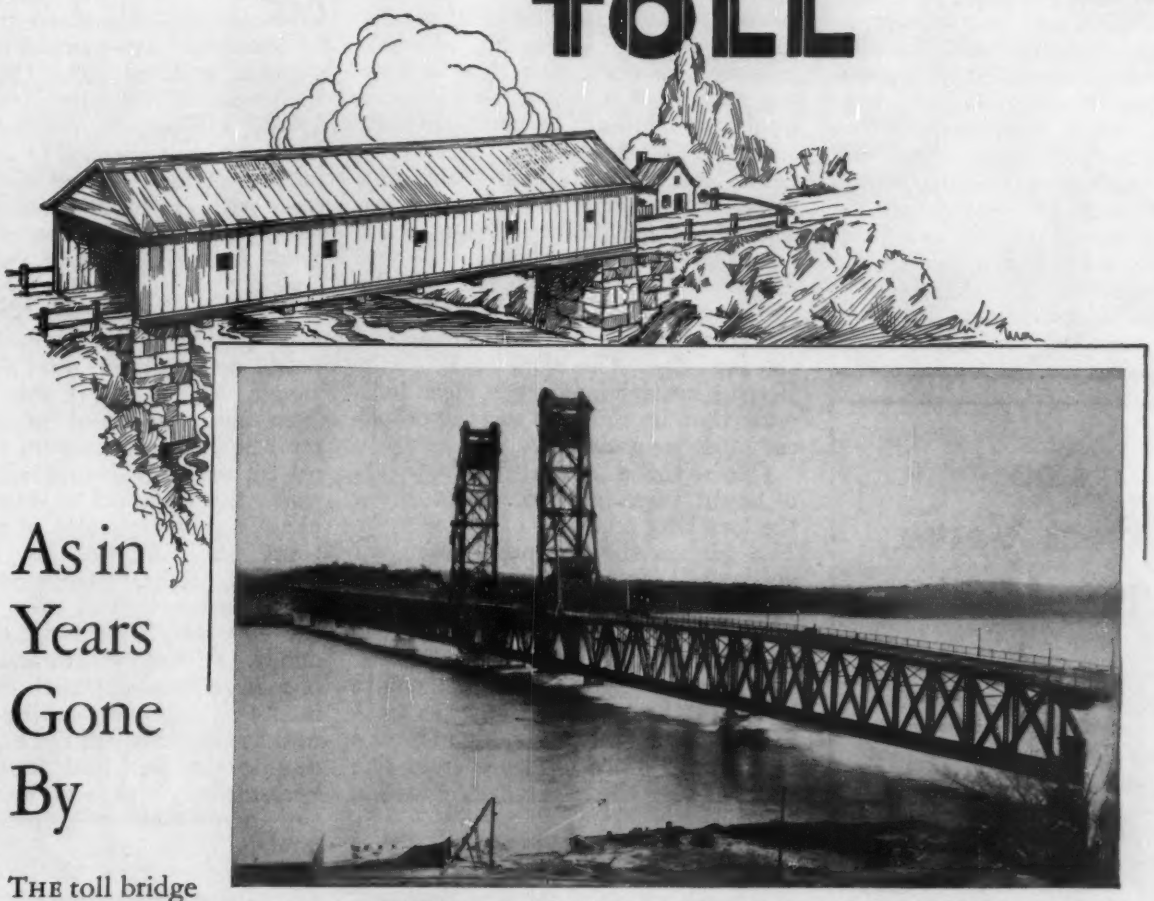

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BUILDERS OF SUPERSTRUCTURES AS WELL AS SUBSTRUCTURES

The Story of Petroleum Refining

(*Continued from page 68*)

covered that under sufficient pressure and temperature and particularly in the presence of certain catalysts, coal could be made to absorb hydrogen and could be almost quantitatively converted into what is substantially a synthetic crude petroleum. While the pressures required are considerable, the success of the Haber technique made it obvious that the industrial practicability of the Bergius method was by no means out of the question. Furthermore, the interesting discovery was made that the low grade coals, lignitic in type, which are decidedly inferior as fuels, respond most readily to the Bergius treatment. Bergius gasoline would cost more than present-day gasoline, but the increase in price would probably not be great. In view of the fact that the known reserves of lignite and similar fuels are enormous, we need have little fear of the consequences of the failure of our crude petroleum supply. Almost the only danger lies in the possibility that the shrinkage in crude might be too rapid to allow for a normal development of the industry. The work of Professor Bergius has rendered even more ludicrous than it originally was the prophesy of dollar gasoline.

One of the important developments of recent years has been the work on the knocking tendency of motor fuels. The higher the compression in an automobile engine, the greater its thermal efficiency. If, however, one tries to use Pennsylvania gasoline under a high compression, the engine knocks. Mid-Continent and Texas gasoline are somewhat better in this regard. California motor fuel is far superior and that from Borneo crudes is from this point of view the best natural gasoline known.

It is important to keep in mind that the cracking process tends to improve the knock rating of gasoline thus produced. Since the automotive designer is always striving for higher efficiency through the use of increased compression in the engine, the chemical engineer must meet the need by improving the knock rating of the motor fuel through every means at his command. This necessity was the impulse underlying the development of tetraethyl lead. Present day information indicates that the synthesis of knock resisting motorfuels will assume a rapidly increasing importance. Thus, methanol, despite its low B. t. u. per gallon, so greatly improves the knocking characteristics of a blend that it may be found to have marked commercial value as a motor fuel. The knocking tendencies of the gasolines produced by the Fischer and Bergius processes have not been adequately determined, but, from the analogies of these processes with cracking, it seems not unlikely that they will be of premium grade from the point of view of anti-knock.

Up to the time, some fifteen years ago, when these developments started, petroleum refining was a relatively simple art. While it was important from the standpoint of mechanical problems, the importance of its chemical phases were almost nil. At that time, the chemical engineer had no place in industry. But at the present time, the situation is completely changed. It has become necessary for the industry to find men to operate the processes that have been introduced. It must secure another group of men to keep step with the developments which are taking place so rapidly in this field. Furthermore, despite the fact that these men are necessarily young and inexperienced, the industry must give to the best among them many responsibilities which are out of all proportion to their age and the extent of their experience, because of the fact that the older generation which the industry has inherited, and from which its present executives would normally be drawn, lacks so completely not only the chemical background, but also the actual training so essential for achievement under the exacting conditions of the present day. It is for these reasons that the motor fuel industry offers such an excellent opportunity to those young chemical engineers of proper personal capacity and technical ability.

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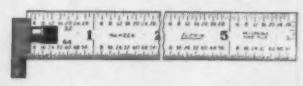

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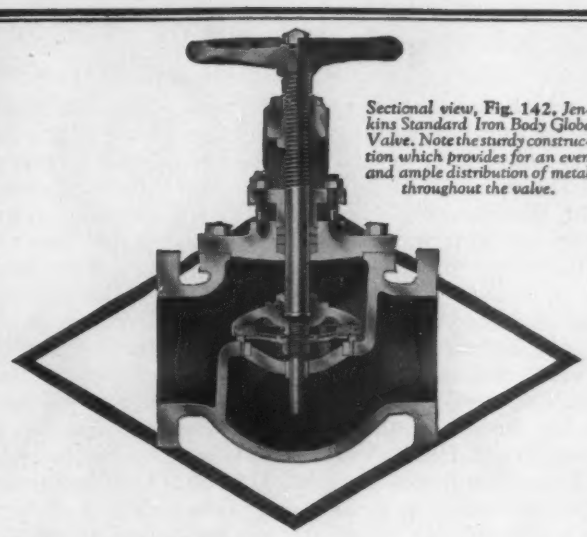

Sectional view, Fig. 142, Jenkins Standard Iron Body Globe Valve. Note the sturdy construction which provides for an even and ample distribution of metal throughout the valve.

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Fig. 715
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Fig. 338
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The National Research Council

(*Continued from page 51*)

tion which have been approved and financed by the committee. A large number of reports on the activities of the Division are available.

The Division of Medical Sciences is at present centering its attention on the following subjects: medical problems of animal parisitology, pharmacalogical research, physical causes of deafness, heredity in disease, industrial medicine, research in infectious diseases. The committee on sex problems has received grants amounting to $66,000 to assist in its work. The General Education Board has given $15,000 to the committee on medicolegal problems to finance its important studies.

The Division of Biology and Agriculture is in charge of the Tropical Research Foundation which has $50,000 at its disposal to study and develop agriculture in tropical countries. It has also funds available to be used in pharmaceutical research.

The Council has received a gift of $235,000 to be used in financing for six years a journal of biological abstracts. It is believed that the publication will eventually become self-supporting.

The Division is formulating a comprehensive program for the coördination of research on a number of problems of the fresh water fisheries industries. It has done notable work in the study of diseases of sugar cane. The Division awards the fellowships maintained for research by the National Livestock and Meat Board.

The Division of Anthropology and Psychology is at present studying through one of its committees the psychology of the highway. Financial aid has been secured to investigate such subjects as safety limits of reduced vision in auto driving, psychological tests for drivers, the visibility of signs, causes of accidents, etc. The mental and physical development of young children is being studied with the assistance of a grant of $10,000 made by the Laura Shalman Rockefeller Memorial. The same organization is financing an investigation of the tactual interpretation of oral speech and of the scientific problems of human migration arising from immigration. The Division is provided with funds for the administration of national intelligence tests.

The Division of Educational Relations has conducted an extensive survey, which included visits to one hundred twenty colleges and universities, of the problem of the gifted student, and has published a report of its findings. A committee of the Division is investigating research in colleges, as distinct from universities, and with the coöperation of a number of scientific organizations is working out a plan to increase the opportunities and facilities in these institutions. The Division has circulated widely in public, college and university libraries lists of its bulletins describing the opportunities for a career in scientific research. It has published a number of reports on a survey made of schools for the deaf.

The Council maintains contact with the United States Government through its Division of Federal Relations, with the several states through its Division of States Relations, and with international scientific affairs through its Division of Foreign Relations.

The results of the work of the Council are available through its publications. Sixty-one bulletins and eighty numbers in its reprint and circular series have been issued.

This account of the National Research Council is of necessity far from complete. Enough has been given, however, to show that the Council is fulfilling its functions successfully.

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Departmental Notes

(*Continued from page 60*)

for this and for the numerical results recently obtained when a solid compound of ammonia was used instead of liquid ammonia. The effect is closely associated with the influence of pressure on chemical equilibrium in gases. Experiments and calculations are being continued in an effort to obtain a complete explanation of this influence, which is of importance in the production of synthetic ammonia and methanol. (*L. J. Cillespie.*)

Research is now in progress on the chemistry of the phenanthridone series, and on the synthesis of materials similar to the important Naphthol AS colors, to develop new outlets for the large available supply of phenanthrene and fluorene. Certain of the substances derived from fluorene have been found adapted to a study of the peculiar change known as the Beckmann, rearrangement, whose mechanism needs further investigation. (*E. H. Huntress.*)

The effect of temperature and pressure on the dielectric constants of gases is being investigated, especially for air, argon, helium, hydrogen, ammonia, nitrogen and carbon dioxide. There is a close relation of the dielectric constant to the degree of polarization of a molecule. In order to perfect our knowledge of the equation of state for fluids, it is necessary to determine the diameter of the molecule and the cohesive pressure by methods which do not involve measurements of p, v, and T. The specific heats of liquids and gases as functions of the temperature and pressure are being measured from the range — 183 to 100 C. and between 50 and 100 atmospheres pressure. (*F. G. Keyes.*)

Acetoacetic ester is a representative of the class of compounds whose condensation products yield synthetic resins. The mechanism of this condensation in the presence of alkali is being investigated. A knowledge of the effect of external conditions upon the character and properties of the products may lead to better methods of controlling the rate of formation of these resins. (*A. A. Morton.*)

The former large work on identification of organic compounds is being revised and condensed within the limits of a single volume, and is to be preceded in that volume by a new outline for the separation of mixtures of organic substances into their constituents. (*S. P. Mulliken.*)

The preparation of gasoline by cracking of hydrocarbons of high molecular weight (as carried out in industrial refining) involves so many simultaneous reactions that no study of their mechanism is possible. Studies of single compounds in which only one bond is severed by heat are being conducted. Other experiments have already shown the selective influence of catalysts in relation to the bond

(*Continued on page 80*)

The Integraph

(*Continued from page 66*)

complicated functions. Once all engineering works were designed by rule of thumb. Then engineers began to analyze the simpler aspects of their problems, and to predict performance. We now treat mathematically and for specific purposes even complex interrelationships in structures; electrical, thermal, and mechanical machines; and chemical processes. We once balanced machines by cut and try, but now by dynamic balancing machines. We once steered ships by following a star or a magnetic compass; now a gyroscope automotically steers the ocean liner. We once walked, we now fly. We once considered mathematicians and engineers as races apart. The day will come when we shall enable the mathematician to play fully that part in progress to which he is entitled by his attainments, always far in advance of the part of them that the plodding engineer can understand. Before that time comes we must have more machines into which can be delivered facts, and out of which can be taken derived relationships; equation solvers, whether the equations be algebraic, total or partial differential, or integral. These are machines that think, certainly, for one aspect of "to think" is simply to combine observations into relationships. They think in the way an adding machine thinks, the type of mechanical thinking that is repetitive and hence properly a machine process, and that frees the operator for that higher type of non-repetitive thinking which makes for progress.

Synthetic Methanol is now made by two new methods. One company utilizes a mixture of approximately equal volumes of hydrogen and carbon dioxide obtained as by-products of its fermentation operations, and converts the mixture directly to methanol. Another company uses the methanol reaction to remove carbon monoxide from the nitrogen-hydrogen mixture obtained from the water gas reaction. This is then passed on to the Claude ammonia converters.

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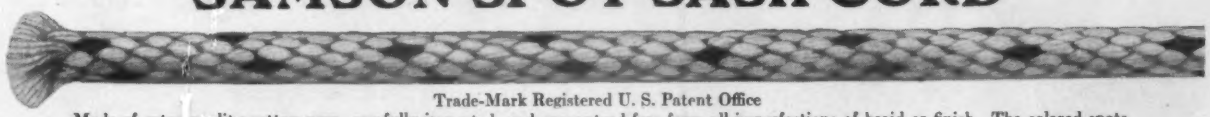

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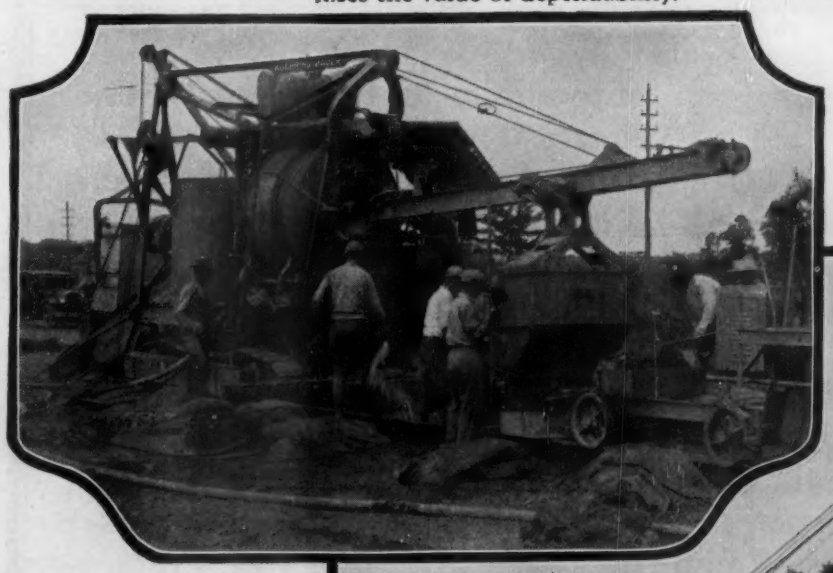

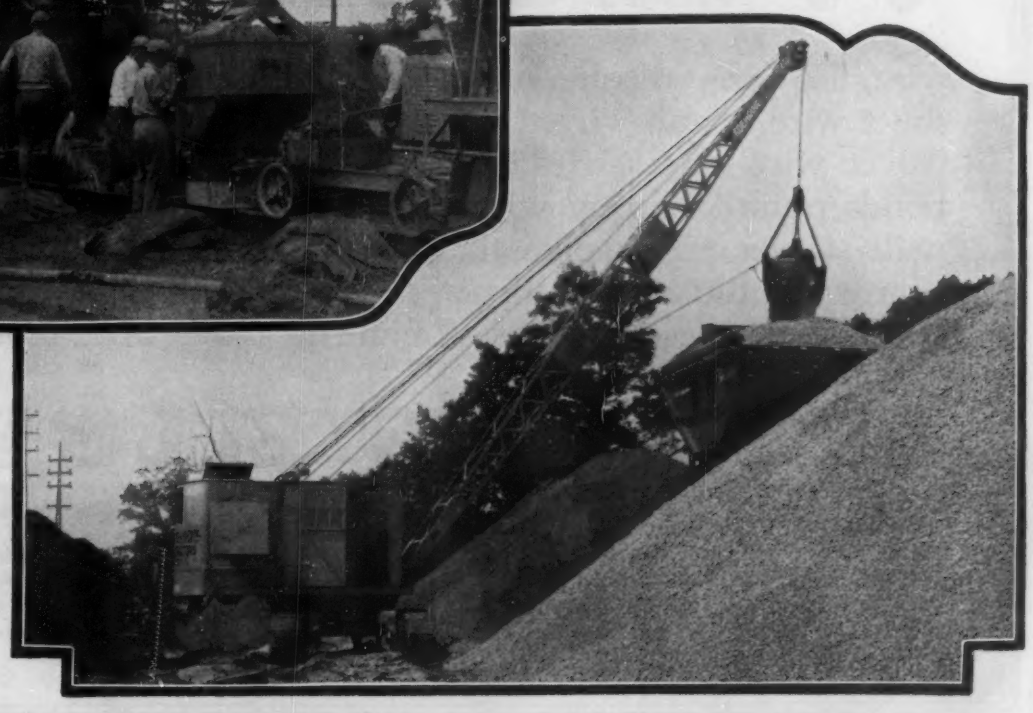

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Departmental Notes

(*Continued from page 78*)

severed in compounds where more than one decomposition is possible. Certain materials which result from the cracking of petroleum yield tertiary alcohols and from these isoprene (the parent substance which polymerizes to rubber) may be prepared. Another investigation relates to the reaction between sulphuric acid and diolefines. In spite of the wide industrial use of this reaction its nature is not understood. Gasoline which contains diolefines behaves in a manner similar to gasoline containing tetra-ethyl lead. The chemistry of these diolefines is being investigated. Laboratory methods recently made available are being applied to the study of unsaturated hydrocarbons of high molecular weight. Other new methods are being sought in order to open up this important field. (*J. F. Norris.*)

Studies of organic addition compounds are being carried out to extend some of the chemical theories relating to ammonium, oxonium and carbonium salts. (*J. Piccard.*)

A study of electrolytric solutions (especially those containing more than one non-electrolyte) such as salt solutions in mixtures of water and alcohol is under way. The properties studied are electromotive force of cells, solubility of salt or of non-electrolyte, vapor pressure and freezing point of solvent, and heat of dilution. An attempt is being made to correlate these properties with a simple physical theory, the basis of which is Debye's treatment of the electrostatic forces between ions. (*George Scatchard.*)

A new method has been worked out for preparing silicon tetrachloride from cuprous chloride and silicon which yields nearly pure tetrachloride. Starting with this material the possibility of its reduction to a lower chloride by silicon is being investigated. Later work will be concerned with the other halides. (*W. C. Schumb.*)

Equilibrium between the substances chlorine, hydrochloric acid, selenous acid and selenic acid is being investigated in order to determine the potential of the selenous acid electrode. Supplementary measurements involving bromine and hydrobromic acid in place of chlorine and hydrochloric acid are in progress. These measurements lead to the free energy changes accompanying the reaction, from which in turn may be calculated the chemical equilibrium of reactions between selenous and selenic acids and other substances. (*M. S. Sherrill and E. F. Izard.*)

Measurements of the gaseous products of metabolism in men and women yield data from which the energy expended and the efficiency of work may be computed. Experiments are in progress for collecting date of this character. (*H. M. Smith.*)

The relation between chemical structure and the physical properties of organic compounds can be studied only when highly pure substances are available. With such a study in view, the methyl esters of the homologous saturated fatty acids are being purified by fractional crystallization. Since these substances are liquids which freeze 40° to 100° below zero centigrade, they required the development of a special technique. The purity of the esters is followed by means of cooling curves, and thus the freezing points of the pure compounds are being determined. Other series of homologues and isomers will be included in the study. (*Evald L. Skau.*)

Steam tables are being revised up to pressures of 600 pounds and extended from this pressure to the critical pressure. Compressibilities, and liquid and vapor saturation specific volumes are being measured up to 5000 pounds pressure. The p, v, T relations in the

(*Continued on page 82*)

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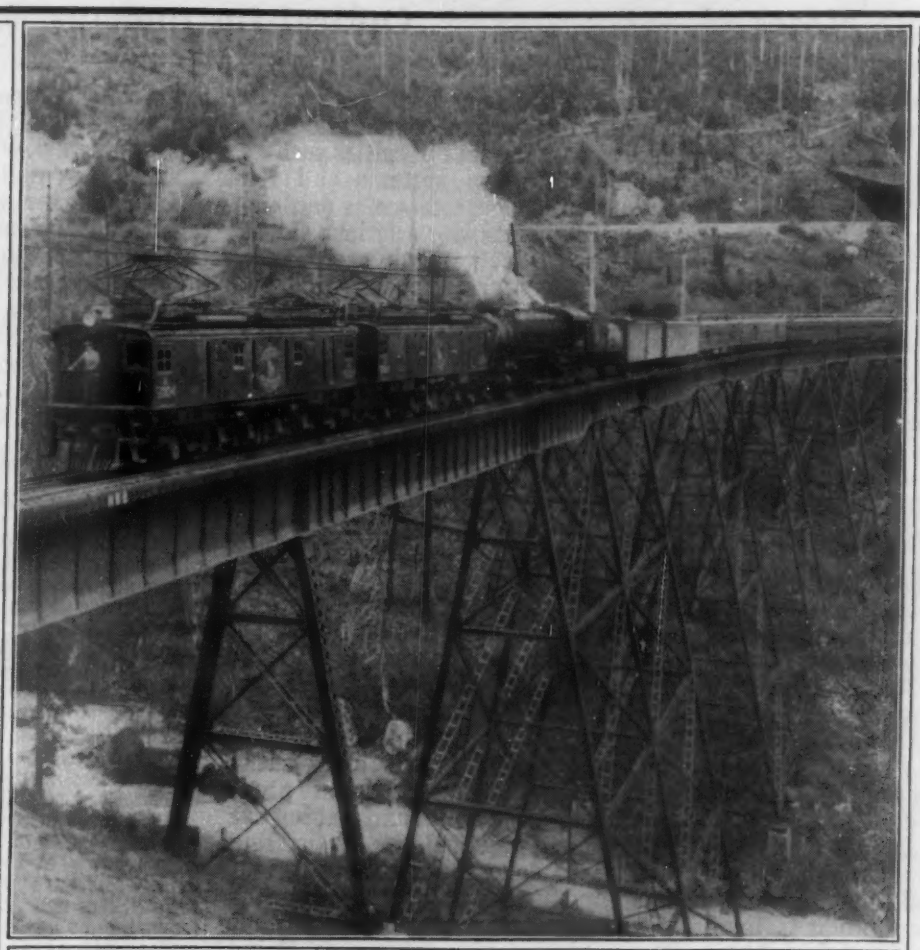

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A noteworthy feature of the Great Northern electrification is the use of motor-generator electric locomotives. These new-type locomotives draw high-voltage alternating-current power from the wire and convert it, on the locomotive, into low-voltage direct-current power for the driving motors. This system eliminates the need of substation power-converting equipment along the railroad right-of-way.

Westinghouse

Departmental Notes

(*Continued from page 80*)

superheated region are also included in this study. (*L. B. Smith.*)

Reactions of Diphenic acid derivatives are being studied together with their bearing upon theories regarding indicators and fluorescence. Some relationships between the structure of dyestuff molecules and the fastness of colors are under investigation. The influence of catalysts on the behavior of important structural units in representative organic compounds of various types is being investigated. Preliminary studies of the catalyzed reactions of acid derivatives with ethers, and the prevention of oxidations by negative catalysts are nearing completion. (*H. W. Underwood, Jr.*)

Metallic sodium dissolves in liquid ammonia without reacting with the solvent, and organic compounds which react with sodium do so more rapidly in a single phase system. High yields are usually obtained and sometimes the products are of different character from those obtained when the reaction takes place between solid sodium and the organic compound dissolved in ether. Groups such as triphenylmethyl form compounds with sodium dissolved in ammonia and give high yields of substitution products upon reacting with alkyl halides. The nature and character of these reactions is being investigated. (*C. B. Wooster.*)

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Optical Instruments

(*Continued from page 56*)

taken, the problems are even greater than in microscope construction, as there are additional difficulties such as complicated prism systems and the graduation of accurate scales and circles. Temperature variations must often also be dealt with in such a way that the accuracy is not impaired.

The American type of organization formed to bring about the most efficient study of the sort of problem exemplified by the above differs in general, I believe, from the more common European plan.

We consider that optical instrument manufacturing can be lined up according to the usual functional set-up employed by most other manufacturing concerns in this country. There are sales, engineering, manufacturing and service, all as distinctive functional divisions. The engineering division is further functionalized. We have our scientific bureau whose chief problems are optical. A technical bureau who, with the optical layout as a basis, develop the mechanical structure properly housing the optics and making use of them in a practical way. A drafting bureau to take the resulting instrument and further whip it into shape for actual production, making a further study of ease of manufacture, lining up material lists, drawings and other specifications, paying a great deal of attention to interchangeability of parts with other instruments, and interchangeability of materials as much as possible so as to permit working with minimum inventories and still give a maximum of service. Although variety is great and quantities comparatively small in the optical instrument business, these phases of the work must be controlled to almost as great an extent as in the plant which has much less variety and larger quantity production.

An inspection bureau is included in the engineering division to inspect and control the quality of all finished product as delivered to the user. This department maintains close touch with the other sub-divisions so that they are well prepared to inspect and test the results in a scientific and practical manner.

Although this form of organization is probably an ideal arrangement, it cannot function unless it has a great deal of flexibility. There must be perfect coöperation and a willingness to break down the departmental barriers when circumstances warrant. European practice seems to favor the scheme of having one engineer handle pretty nearly all phases of the work including manufacturing of a very limited range of instruments rather than follow our practice of having one man handle one phase of the work for a large number of instruments. Both schemes are undoubtedly based on racial characteristics. The American scheme calls for more team work which the American engineer undoubtedly possesses to a much greater extent than his cousins across the water.

Book Reviews

(*Continued from page 64*)

matter could be regenerated through the condensation of radiant energy into fixed energy.

The little book which we are reviewing deals with some of the subject matter of last year's lecture and in fact with practically every topic of the newer physics which can be mentioned non-mathematically. The book consists of ten lectures supposed to be delivered to laymen of good intelligence but without mathematical training or any extensive knowledge of physics or chemistry. The author has set himself a very difficult task. He has given the information he set out to give, and the book will be serviceable as a reference book for qualitative information concerning atomic physics.

One cannot help comparing this book with two masterpieces of popular treatment of subjects relating to the constitution of matter, namely Millikan's "The Electron," and Eddington's "Stars and Atoms." These two are as fascinating as any tales of adventure and the reader, although his understanding depends in large measure upon his familiarity with physical science, cannot fail to grasp the spirit of the argument.

On the other hand Dr. Haas attempts a general impartial presentation of all the material which it is possible (it is doubtful if all of it *is* possible) to present to his audience, rather than restricting his field to a single main line of argument. The paragraphs follow each other in a bewildering and sometimes disjointed manner and the whole is rather dull reading. The author in his preface says, "The lectures can lay claim to the characterization 'popular' only in the sense that, as the author hopes, every lay reader who has at his command a sufficient general education can begin the reading of the book and continue to the end without great difficulty and with comprehension, insofar as his interest in the subject lends him the necessary patience and perseverance." It is quite true that the material is given for the comprehension that the author thinks possible, but the amount of patience and perseverance necessary would probably be better expended in acquiring the mathematical skill requisite to follow more adequate presentations. The author does not seem to possess the skill of Millikan or Eddington of stating in non-mathematical terms the meaning of results obtained by involved mathematical reasoning.

The tenth chapter is given to the Wave Mechanics of the Atom and has been written entirely new by the author for this American Edition, thus embracing hints as to the nature of the advances of the last year or two in a new method of theoretical attack which seems to offer great promise. According to this theory the ultimate *material* constituents of atoms, that is, electrons and protons, are supposed to be merely the localizations of energy at points where waves or wave trains fall in phase. These waves, whatever their nature, may travel at velocities greater than that of light, but the rate of propagation of the energy centers due to the interference of wave groups cannot exceed the velocity of light.

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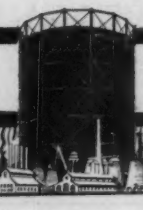

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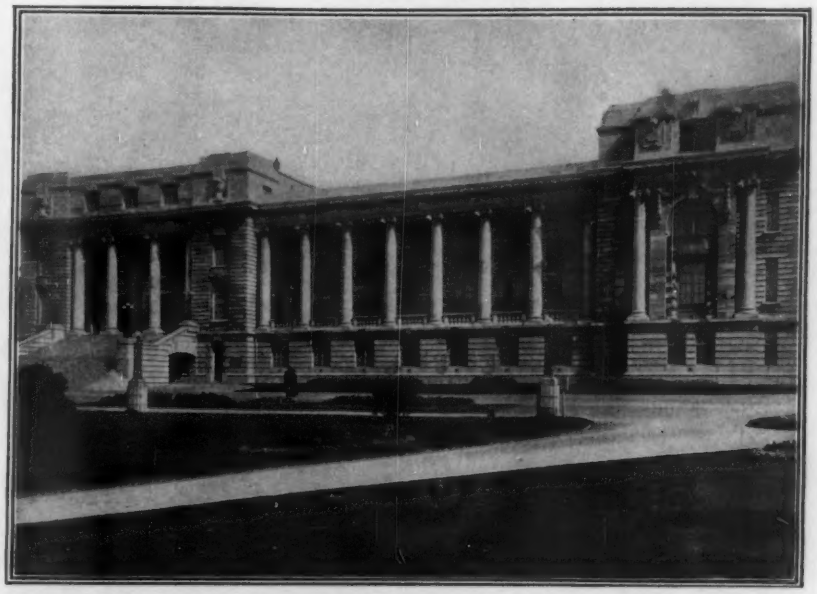

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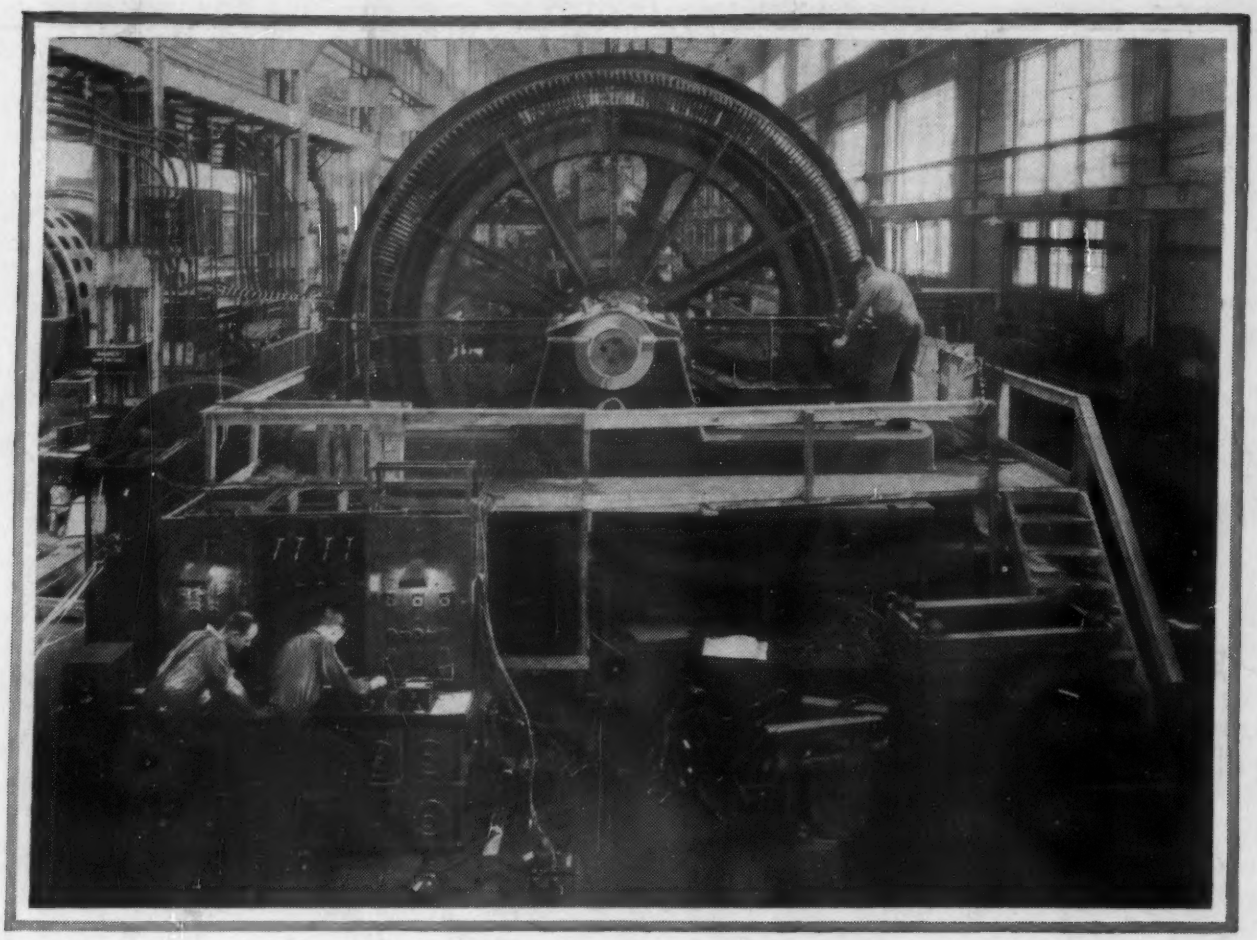

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